

# THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY

Registered at the General Post Office, Melbourne, for transmission by post as a periodical.

VOL. XVIII.

JANUARY, 1949.

No. 3.

## THE REVISION OF THE DERMATOMES.<sup>1</sup>

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In pursuing the study of this subject it is necessary to divest the mind of all preconceived ideas bearing upon it and to note carefully every individual circumstance, however contrary it may appear to one's expectations and desires. One great difficulty is the unreliability of the patient. Pain of the most excruciating kind leaves in the mind but a very imperfect recollection of its exact site. In all cases the description of the pain prior to examination should be received with great caution, and instructions given to note accurately the exact site during an exacerbation or recurrence. In the latter case trustworthy accounts can generally be received even when the observer is not present.

I must confess I have also found it necessary to put a control on my own observations, by having them verified by a colleague. In making my observations I invariably had the most striking and important cases examined independently. Such phenomena as my colleagues could not verify I rejected, for if these sensory symptoms are to be of value they must be capable of being elicited by observers free from bias. And further, cases should not be recorded based upon recollections alone, for it is wonderful how far from the truth memory may wander, when there is a favourite theory to be advanced.

Sir James Mackenzie.<sup>(2)</sup>

### HISTORY.

SOME of the earliest work on the peripheral distribution of spinal nerves was done by Herringham,<sup>(3)</sup> who traced by dissection the course of each spinal nerve through the brachial plexus to the peripheral nerves and thence to its final destination in muscle and skin. Herringham described the dermatomes in the upper limb as accurately as they can be described today, but his work did not attract the attention it deserved. Paterson<sup>(4)</sup> did similar work on the lumbo-sacral plexus.

Sherrington<sup>(5)</sup> carried out a large number of experiments in monkeys. He divided a number of posterior nerve roots both above and below one given root, thus leaving intact the sensibility of the area of skin supplied by that root. The area so supplied was determined and in this way he defined the touch dermatomes in the monkey. These overlapped to such a degree that it appeared that division of a single nerve root produced no loss of sensibility.

Head<sup>(6) (7)</sup> studied the distribution of areas of cutaneous tenderness in visceral disease and compared them with the distribution of the rash in a large number of cases of *herpes zoster*. He also noted the limits of analgesia

<sup>1</sup> Read at the annual meeting of the Royal Australasian College of Surgeons at Dunedin, January 30, 1948. Accepted for publication on April 23, 1948.

in a few cases of organic disease of the spinal cord and nerve roots. Upon these observations he drew charts of the dermatomes in man. Later Head and Campbell<sup>(1)</sup> studied some cases of *herpes zoster* in which the site of the lesion was proved at autopsy. They made some minor alterations to Head's original charts and published Figure I. It should be noted that the areas figured in these charts depend especially upon the distribution of pain fibres and upon the distribution of the rash in herpes. The amount of overlap in these dermatomes is such that, if one nerve root is divided, there will be between the segments above and below the divided root a gap which is innervated only by the affected root. Head was unable to demonstrate any

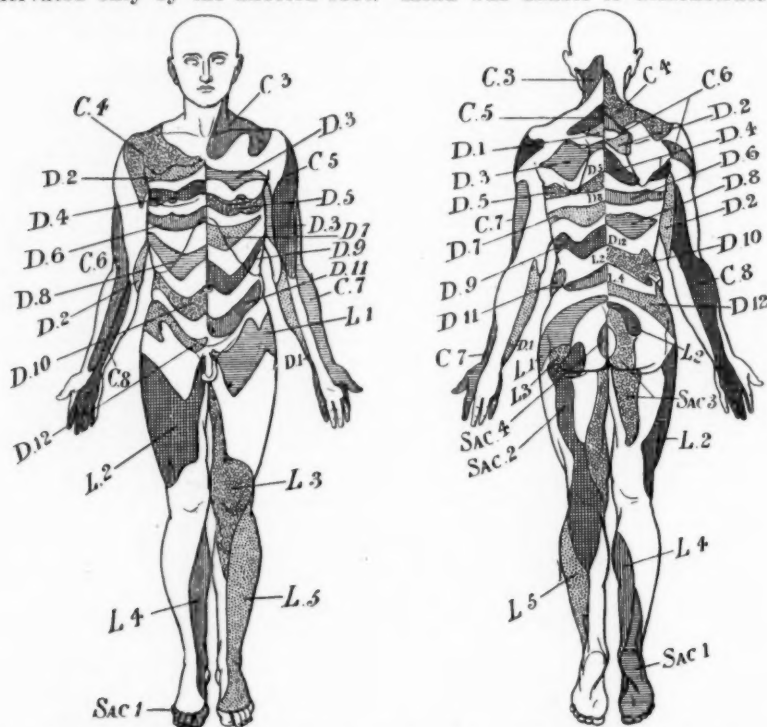


FIGURE I. The dermatomes according to Head and Campbell. (This and other figures from Head's articles by courtesy of the editor of *Brain*.)

loss of touch sense in such areas, but he had noted alterations of pain sensibility. Thus Head's dermatomes, which may be called pain dermatomes or herpes dermatomes, did not overlap to the same extent as did Sherrington's touch dermatomes in the monkey.

Foerster<sup>(2)</sup> divided posterior nerve roots in man and defined areas of remaining sensibility in the same way as Sherrington had done in the monkey. He studied touch sensibility in particular and his results were therefore more in agreement with Sherrington than with Head. He also studied the distribution of cutaneous vasodilatation produced by stimulation of the posterior nerve roots.

Following the demonstration of protrusions of the intervertebral disk in 1934 by Mixter and Barr<sup>(3)</sup> there has been a renewed interest in the problem of root pain and dermatometry, for disk disease has given us an opportunity

to study the effects of lesions of a single nerve root, particularly in the lower cervical and lombo-sacral regions, and this has enabled us to draw the dermatomes in the limbs a little more accurately than did Head.

#### MATERIAL UPON WHICH THE PRESENT STUDY IS BASED.

In the course of the past few years I have had the opportunity of examining some hundreds of patients suffering from radicular pain, but for

this paper no patient was selected for study unless (a) the description of the symptoms was accurate, (b) the pain involved the major portion of the area in which a root pain is usually felt, (c) neurological symptoms or signs were present, (d) the lesion was thought to involve one nerve root only, and (e) the site of the lesion was proved surgically or confirmed radiologically. Admittedly the radiograph may reveal an old healed disk lesion and not reveal an active one, and admittedly two nerve roots are in anatomical relation with each intervertebral disk in the lumbar region. There will therefore be a small percentage of error in this study.

Only the minority of patients satisfied these criteria, so that there remained for study only 119 patients suffering from what was considered to be a root pain involving a single nerve

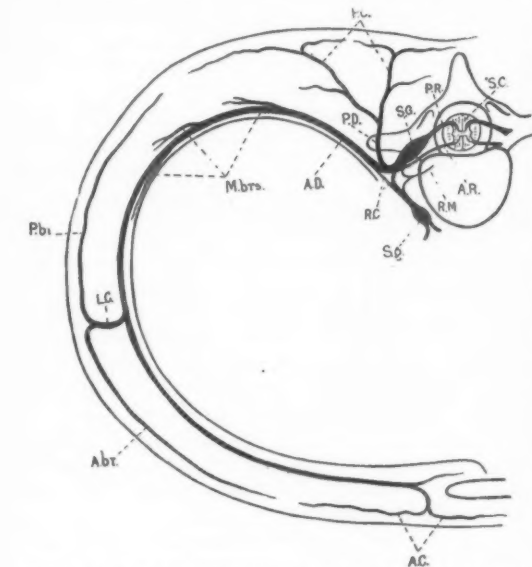


FIGURE II. A typical thoracic nerve: S.C., spinal cord; P.R., posterior root; A.R., anterior root; S.G., spinal ganglion; S.G., sympathetic ganglion; R.M., recurrent meningeal; R.C., *ramus communicans*; A.D., anterior division; P.D., posterior division; P.C., posterior cutaneous; L.C., lateral cutaneous; A.C., anterior cutaneous; M.br., muscular branches; P.br., posterior branch; A.br., anterior branch. (Labat: "Regional Anesthesia", by courtesy of W. B. Saunders Company.)

root. In addition a few cases of *herpes zoster* and one case of segmental scleroderma were studied.

#### SOME EMBRYOLOGICAL AND ANATOMICAL CONSIDERATIONS.

The primitive spinal nerve (Figure II) divides into a posterior and an anterior primary ramus, the former supplying a cutaneous branch to the skin of the back, the latter supplying lateral and anterior cutaneous branches to the skin of the side and front of the body respectively. The primitive dermatome is thus

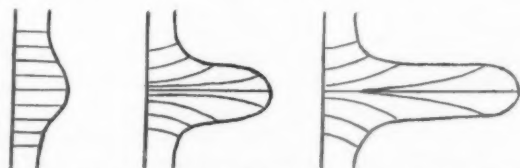


FIGURE III. Development of the limb bud and dermatomes.

a band of skin extending from the posterior mid-line around the body to the anterior mid-line. As the limb bud grows out it drags the dermatomes with it (Figure III), but some of these dermatomes may become separated

from the mid-line during the course of development if the anterior or posterior cutaneous branches of the primitive spinal nerve fail to develop.

It will be remembered that the fifth, sixth, seventh and eighth cervical, the third, fourth and fifth lumbar and the first sacral nerves have no anterior cutaneous branches in fully developed man. The corresponding dermatomes cannot therefore reach the anterior mid-line.

It will also be remembered that the posterior primary rami of the last two or three cervical nerves and of the fourth and fifth lumbar nerves (Figure IV)

give off no cutaneous branches to the skin of the back. The corresponding dermatomes therefore will not reach the posterior mid-line.

Each spinal nerve supplies an area of skin with touch, pain, vasodilator and other nerve fibres. The area of skin so supplied is called the dermatome. The various fibres do not all have the same distribution, so we may therefore speak of touch dermatomes, pain dermatomes, vasodilator (herpes) dermatomes, and so on. Head<sup>(1)</sup> pointed out that failure to differentiate these dermatomes and failure to differentiate spinal nerve lesions from spinal cord lesions have caused confusion in the past.

Both Herringham and Paterson showed by dissection that the spinal nerves overlap and vary in their peripheral distribution.

The touch dermatomes overlap most. Thus irritation of the touch fibres in a nerve root may produce tingling in a more extensive area than any accompanying diminution of touch sense.

The pain dermatomes overlap less than the touch dermatomes. Thus a lesion of a nerve root will produce a greater diminution of pain sense than of touch sense, and diminution of pain sense is more common than diminution of touch sense. The vasodilator dermatomes are involved in *herpes zoster* and they

appear to correspond fairly closely to the pain dermatomes. It is difficult to determine the extent of the touch dermatomes, for they overlap considerably and disturbances of touch sense are less common than disturbances of pain sense. The extent of the pain and herpes dermatomes is relatively easy to determine, so I will confine myself especially to these dermatomes.

#### THE FIFTH CERVICAL DERMATOME.

In two patients with lesions of the fifth cervical nerve pain radiated to the antero-lateral aspect of the arm, that is, to the area in which Head placed the fifth cervical dermatome. In one pain sense was diminished over the deltoid, there was weakness of the deltoid muscle, and the deltoid reflex was absent. In the other touch and pain senses were diminished over the



FIGURE IV. Cutaneous branches of the posterior primary rami of the spinal nerves. (From "Gray's Anatomy", by courtesy of Longmans, Green and Company.)



deltoid muscle. The first lesion was confirmed surgically, the second radiologically.

Keegan<sup>(11)</sup> includes the clavicular region in this dermatome (Figure V), but I would doubt if this is often the case, for the fifth cervical nerve supplies no cutaneous branches to this area.

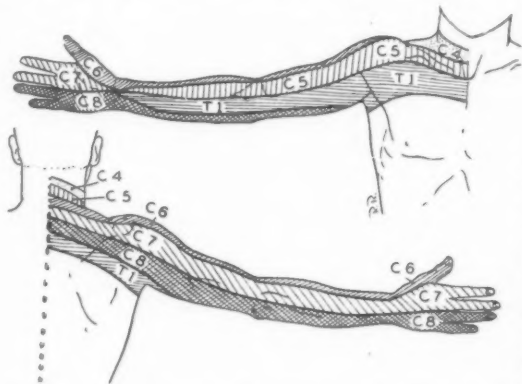


FIGURE V. Dermatomes of the upper limb according to Keegan.

antero-lateral part of the arm and the antero-radial part of the forearm, and perhaps to the thumb, index and middle fingers. Sensory disturbances occur especially in the antero-radial aspect of the forearm and in the thumb. There may be weakness of flexion of the elbow and diminution or absence of the biceps and supinator jerks.

Figure VII shows the affected area of skin in a patient with scleroderma apparently localized to the sixth cervical segment. The biceps and *supinator longus* muscles were fibrosed and the corresponding reflexes absent.

Recent experience would therefore suggest that the sixth cervical dermatome should include the radial aspect of the forearm as well as the area in which Head has placed it.

It should also be noted that the upper part of the dermatome will reach to the posterior mid-line only if the posterior primary ramus has a cutaneous branch.

In one patient with a proved lesion of the sixth cervical nerve (not included in Table I) the features were characteristic of a seventh cervical nerve lesion. Thus the radicular syndromes and therefore the dermatomes may vary from one patient to another.

Head drew the seventh cervical dermatome from a case of *herpes zoster* (Figure VIII) in which the site of the lesion was not proved; but it can be shown that this case is not a herpes of the seventh segment. First, the

#### THE SIXTH CERVICAL DERMATOME.

Head drew the sixth cervical dermatome from a case of *herpes zoster* (Figure VI) in which the site of the lesion was not proved, but it is not possible to say whether this is a herpes of the fifth or sixth cervical segments. It could be a laterally placed fifth or a medially placed sixth segment.

Sixth cervical root pain (Table I) radiates to the

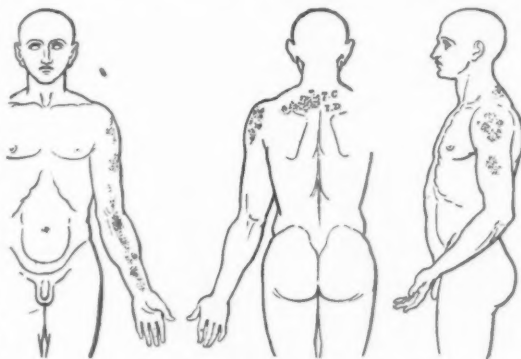


FIGURE VI. *Herpes zoster* of the fifth or sixth cervical segment. (Head considered this a case of *herpes zoster* of the sixth cervical segment.)

rash is confined to the area in which the sixth cervical dermatome has just been placed. Second, the upper part of the rash is in the deltoid area, which is supplied by the circumflex nerve, and in forty-three dissections Herringham never found fibres of the seventh nerve entering the circumflex. Third, the

TABLE I.  
Fifteen Cases of Sixth Cervical Root Pain, Showing Numbers of Cases of Each Type of Disturbance

Area.	Pain.	Tingling.	Numbness.	Hypo- aesthesia.	Hypo- algnesia.
Anterior aspect of arm .. .. .	1	1	—	—	—
Antero-lateral aspect of arm .. .	9	2	—	—	—
Lateral aspect of arm .. .. .	5	—	—	—	—
Radial part of palmar aspect of forearm ..	6	2	—	2	3
Radial aspect of forearm .. .. .	8	2	1	4	4
Radial part of dorsal aspect of forearm ..	1	1	—	—	—
Thumb .. .. .	5	6	8	4	5
Index finger .. .. .	4	5	4	3	4
Middle finger .. .. .	3	2	3	2	2

Fibrillary tremor in the biceps, 1 case; weakness of flexion of the elbow, 3 cases; biceps jerk diminished in 1 case; biceps and supinator jerks absent in 2 cases. Confirmation—surgical in 2 cases, radiological in 13 cases.

lower part of the rash is in the area supplied by the musculo-cutaneous nerve and in thirty-nine dissections Herringham only once found fibres of the seventh nerve entering the cutaneous branch of that nerve. Is it not more likely that Figure VIII is an example of herpes of the sixth cervical segment, in which the posterior primary ramus of the sixth cervical nerve has no cutaneous branch?

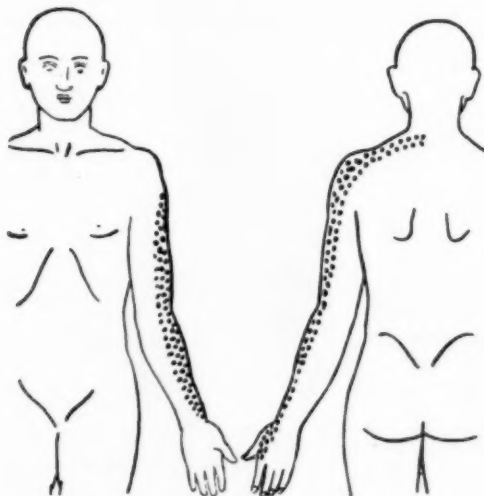


FIGURE VII. Skin lesions in a patient with segmental scleroderma. (Author's case.)

the postero-lateral aspect of the arm to the dorsal aspect of the forearm, and especially to the index and middle fingers. Sensory disturbances may occur in the dorsal aspect of the forearm and in the affected digits. There may be weakness of extension of the elbow and fingers, and diminution or absence of the triceps jerk.

Figure X shows the distribution of the most extensive sensory changes I have found in a patient with a seventh cervical root pain. The dermatome

#### THE SEVENTH CERVICAL DERMATOME.

Between the sixth cervical dermatome laterally and the first and second thoracic dermatomes (*vide infra*) medially there is an area of skin on the back of the arm and the dorsal surface of the forearm and hand which the seventh and eighth cervical dermatomes will occupy and overlap (Figure IX). We know from embryological considerations that the seventh dermatome will occupy the lateral part of this area and the eighth the medial part.

Seventh cervical root pain (Table II) radiates via

should therefore be placed more dorsally than Head placed it. In patients with seventh cervical root pain I have not found sensory changes higher than shown in Figure IX, but tingling may occur in the outer aspect of the arm,

so perhaps the dermatome should reach up to the shoulder; but it cannot reach the posterior mid-line (as in charts published recently by Keegan<sup>(m)</sup> (Figure V) and by myself<sup>(n)</sup>), as the posterior primary division of the seventh cervical nerve has no cutaneous branch.

In searching through the literature I have found no records of cases of *herpes zoster* affecting the seventh or eighth cervical segments.

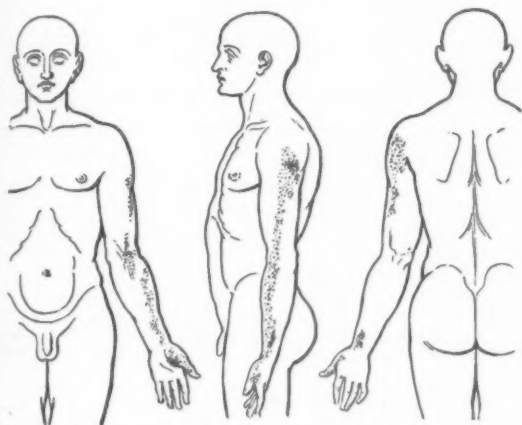


FIGURE VIII. *Herpes zoster* of the sixth cervical segment. (Head considered this a case of *herpes zoster* of the seventh cervical segment.)

#### THE EIGHTH CERVICAL DERMATOME.

Head drew the eighth cervical dermatome from

Figure XI, which he thought was a herpes of the eighth cervical segment; but he must have had some doubts about it, for it will be noted that in Figure I he did not put any of the eighth cervical dermatome on the anterior aspect of the biceps, as is the case in Figure XI. In this case also the site of the lesion was not proved at autopsy. Part of the rash is in the area of the sixth cervical dermatome, and I think it is obvious that Figure XI is a herpes of more than one segment (perhaps of the sixth and eighth cervical segments) and therefore I doubt if it is wise to attempt to draw any conclusions from this case.

I have had only one case of eighth cervical root pain. Pain radiated to the posterior part of the arm, ulnar part of the dorsal aspect of the forearm, index, middle and ring fingers. Tingling and numbness were present in these digits. There was an area of exquisite hyperalgesia in the posterior arm, dorsal forearm, middle and ring fingers (Figure XII). The triceps reflex was diminished.

The eighth cervical dermatome cannot reach the posterior mid-line (as in the charts previously referred to), for the posterior primary division of the eighth cervical nerve has no cutaneous branch. We know that it occupies and overlaps the medial part of the gap shown in Figure IX. It probably occupies the area shown in Figure XII,

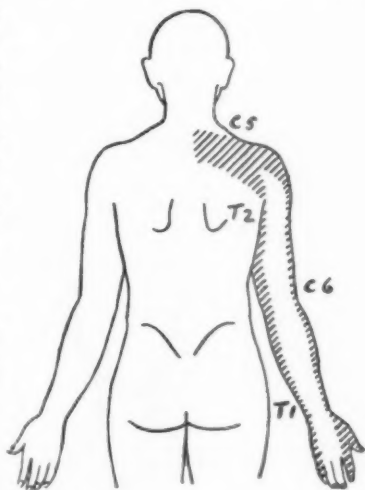


FIGURE IX. The gap on the back of the upper limb which is occupied and overlapped by the seventh and eighth cervical dermatomes.

and we know that this area can be supplied by the eighth cervical nerve through various cutaneous nerves. Herringham found that the dorsal cutaneous branch of the ulnar nerve was almost always formed of fibres from the eighth cervical nerve alone.

TABLE II.

*Nineteen Cases of Seventh Cervical Root Pain, Showing Numbers of Cases of Each Type of Disturbance.*

Area.	Pain.	Tingling.	Numbness.	Hypo- aesthesia.	Hypo- aesthesia.
Posterior aspect of arm .. .. .	3	—	—	—	—
Postero-lateral aspect of arm .. .	1	—	—	—	—
Lateral aspect of arm .. .. .	15	2	2	—	—
Dorsal aspect of forearm .. .. .	18	—	2	2	3
Radial aspect of forearm .. .. .	1	1	—	—	—
Back of hand .. .. .	—	1	—	2	3
Thumb .. .. .	7	8	10	4	6
Index finger .. .. .	12	13	13	7	11
Middle finger .. .. .	9	12	12	9	12
Ring finger .. .. .	3	5	5	2	3
Little finger .. .. .	1	2	2	1	1

Weakness of extension of the elbow in 5 cases and of the fingers in 2 cases; triceps jerk diminished in 7 cases and absent in 6 cases; biceps and supinator jerks diminished in 1 case and absent in 1 case. Confirmation—surgical in 1 case and radiological in 18 cases.

### THE FIRST AND SECOND THORACIC DERMATOMES.

Herringham found that the medial brachial cutaneous and the medial antibrachial cutaneous nerves and the palmar cutaneous branch of the ulnar nerve were almost always formed of fibres of the first thoracic nerve only

and that this nerve did not enter into the formation of any other cutaneous nerves. The distribution of the first thoracic dermatome can be determined from the distribution of these nerves. It will include the inner aspect of the arm, the ulnar half of the palmar surface of the forearm, the hypothenar eminence, and the palmar surface of the ring and little fingers. This is the area in which sensory changes occur when the first thoracic nerve is involved by carcinoma of the apex of the lung.

The distribution of the second thoracic dermatome is known from the anatomy of the nerve and its intercosto-brachial branch. It will include the inner aspect of the arm, but should lie more anteriorly than shown by Head.

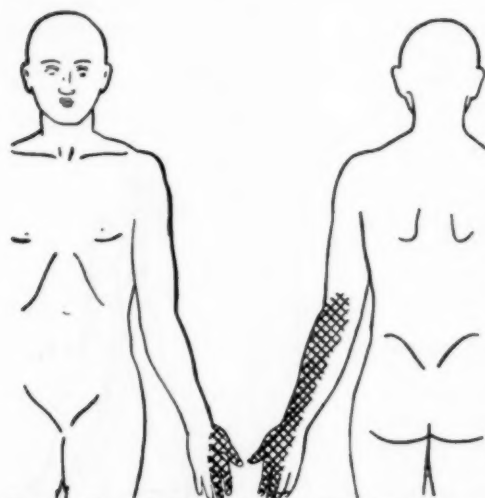


FIGURE X. Hypoaesthesia and hypoaesthesia in a patient with a seventh cervical root pain. (Author's case.)

Figure XIII was published by von Bärensprung.<sup>(13)</sup> It is a case of *herpes zoster* affecting the second thoracic segment.

### THE SECOND LUMBAR DERMATOME.

Head's second lumbar dermatome was based upon a spinal cord lesion and it should be emphasized that the cutaneous segmental distribution of a

spinal cord lesion may differ from that of a nerve root lesion. Figure XIV is the case of *herpes zoster* which Head originally believed to involve the

first lumbar segment, but anatomists and neurologists did not agree with this, for the first lumbar nerve gives origin only to the ilio-hypogastric and ilio-inguinal nerves and cannot supply this area. These critics believed that Figure XIV was a herpes of the second lumbar segment. It is somewhat strange that Head and Campbell did not use this case in drawing Figure I. I have seen three cases of *herpes zoster* involving almost exactly the same area as is affected in this case; several are published in the literature and I believe that this is the true distribution of the second lumbar dermatome.

In one of my patients with a proved lesion of the second lumbar nerve, pain radiated to the upper half of the anterior aspect of the thigh and pain sense was diminished in the inner part of this area.

### THE THIRD LUMBAR DERMATOME.

Head's third lumbar dermatome is apparently based upon a case of *herpes zoster* published by Mackenzie<sup>(94)</sup> (Figure XV). Head did not draw the third lumbar dermatome up to the posterior mid-line, though in Figure XV it does reach it. It will also be remembered that the posterior primary ramus of the corresponding nerve supplies this area (Figure IV), and Foerster found an area of



FIGURE XIII.  
*Herpes zoster* of the second thoracic segment. (Von Bärensprung's case.)

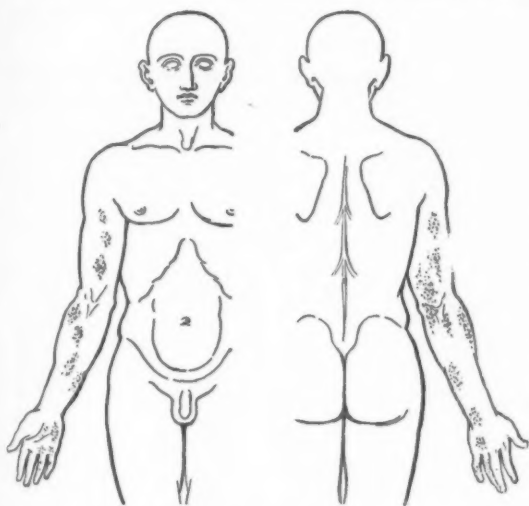


FIGURE XI. Pfeiffer's case of *herpes zoster*. (Head considered this a *herpes zoster* of the eighth cervical segment.)

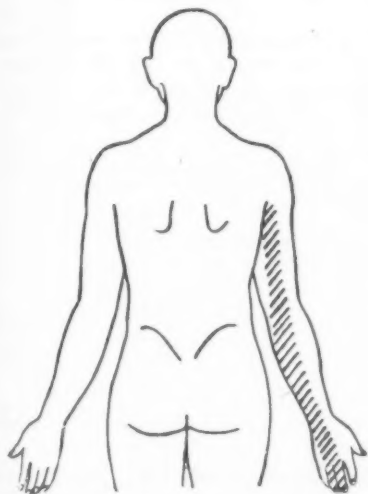


FIGURE XII. Hyperalgesia in a patient with an eighth cervical root pain. (Author's case.)

remaining sensibility next to the posterior mid-line in a case in which he had divided nerve roots both above and below the third lumbar nerve. Third lumbar root pain (Table III) radiates to the antero-lateral aspect of the thigh and perhaps to the upper part of the antero-medial aspect of the leg. Sensory disturbances occur especially in the antero-lateral aspect of the thigh and perhaps in the upper part of the

antero-medial aspect of the leg. There may be weakness of the quadriceps and diminution of the knee jerk. The cremaster reflex may not be obtained when the lower and inner part of the thigh is scratched.

#### THE FOURTH AND FIFTH LUMBAR DERMATOMES.

I believe that Head drew these dermatomes almost as accurately as we can draw them today. Keegan<sup>(12)</sup> has recently drawn a chart (Figure XVI) in which all the lumbar dermatomes run from the posterior mid-line to the periphery. There are several anatomical objections to this chart. The fourth and fifth lumbar dermatomes will not include the skin of the

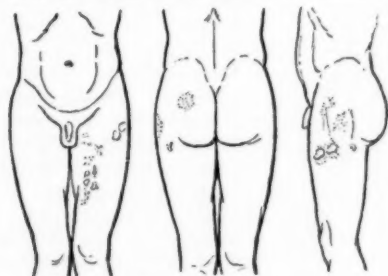


FIGURE XIV. *Herpes zoster* of the second lumbar segment. (Head originally considered this was a *herpes zoster* of the first lumbar segment.)

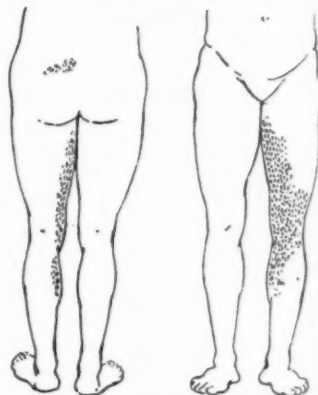


FIGURE XV. *Herpes zoster* of the third lumbar segment. (Mackenzie's case.)

back if the posterior primary rami of the corresponding nerves supply no cutaneous branches to this area (Figure IV). The fourth lumbar dermatome cannot include the outer aspect of the thigh, which is supplied only by the second and third lumbar nerves through the lateral cutaneous nerve of the

TABLE III.

Eight Cases of Third Lumbar Root Pain, Showing Numbers of Cases of Each Type of Disturbance.

Area.	Pain.	Tingling.	Numbness.	Hypo- esthesia.	Hypo- algesia.
Lateral aspect of thigh .. .. .	1	—	—	1	1
Antero-lateral aspect of thigh .. .. .	3	—	—	2	2
Anterior aspect of thigh .. .. .	3	1	1	—	—
Anterior aspect of thigh and upper half of antero-medial aspect of leg .. .. .	1	—	—	—	—
Upper half of antero-medial aspect of leg .. .. .	—	—	—	1	1

Wasting of the quadriceps present in 2 cases; weakness of extension of the knee, 3 cases; weakness of flexion of the hip, 1 case; knee jerk diminished in 5 cases; cremaster reflex diminished in 1 case. Confirmation—surgical in 2 cases, radiological in 6 cases.

thigh, and the fifth lumbar dermatome can seldom include any area above the knee when the cutaneous branches of the fifth lumbar nerve seldom supply any skin above the outer side of the knee. A further objection to Keegan's charts is that they allow no variation in the distribution of the dermatomes—variations which, I am sure, most observers would allow.

Fourth lumbar root pain (Table IV) radiates to the antero-lateral part of the thigh, to the front of the knee, to the antero-medial part of the leg, and sometimes to the medial part of the foot. Sensory disturbances occur especially in the antero-medial aspect of the leg, occasionally in the medial aspect of the foot or great toe. I have not observed them more than a few



inches above the knee. Weakness of the quadriceps may be present. The knee jerk may be diminished or absent.

Figures XVII and XVIII show the areas of sensory disturbances in two patients with lesions of the fourth lumbar nerve. The fourth lumbar

dermatome may therefore include the front of the knee as well as the area in which Head placed it. Figure XIX is a case of *herpes zoster* seen by myself. It apparently involves most of the fourth lumbar dermatome. Taylor<sup>(10)</sup> describes a similar case.

Fifth lumbar root pain (Table V) radiates to the postero-lateral part of the thigh, to the antero-lateral or postero-lateral part of the leg, and sometimes to the dorsum of the foot and the inner toes. Sensory disturbances occur especially in the antero-lateral aspect of the leg, the dorsum of the foot and the inner toes. I have not observed them above the knee. There is

often weakness of dorsiflexion of the toes, less

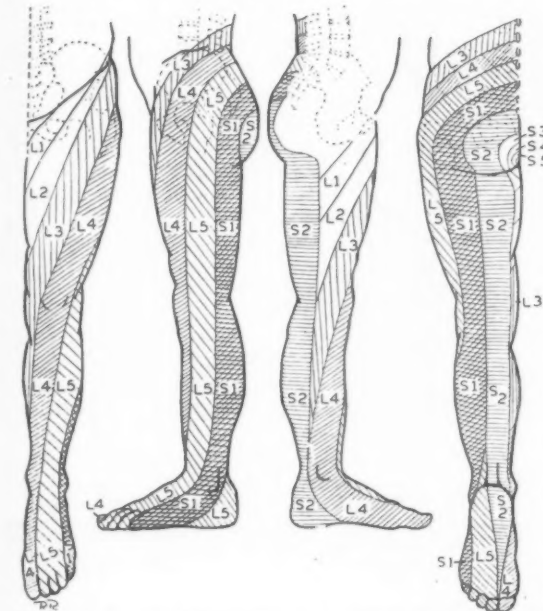


FIGURE XVI. The dermatomes of the lower limb according to Keegan.

often weakness of plantar flexion of the ankle. The ankle jerk is often diminished, occasionally absent.

TABLE IV.

Seven Cases of Fourth Lumbar Root Pain, Showing Numbers of Cases of Each Type of Disturbance.

Area.	Pain.	Tingling.	Numbness.	Hypo-æsthesia.	Hypo-algesia.
Lateral aspect of thigh .. .. .	1	—	—	—	—
Antero-lateral aspect of thigh .. .. .	2	—	—	—	1 <sup>1</sup>
Anterior aspect of thigh .. .. .	4	—	—	—	—
Medial aspect of knee .. .. .	—	1	—	—	—
Anterior aspect of leg .. .. .	1	—	1	2	4
Antero-medial aspect of leg .. .. .	2	—	1	1	2
Medial aspect of foot .. .. .	1	—	—	1	1
Great toe .. .. .	—	—	—	—	1

Cramp in the quadriceps, 1 case; fibrillary tremor in the quadriceps, 3 cases; wasting of the quadriceps, 2 cases; weakness of extension of the knee, 3 cases; weakness of dorsiflexion of the ankle, 1 case; weakness of dorsiflexion of the great toe, 1 case; knee jerk diminished in 3 cases; knee jerk absent in 3 cases. Confirmation—surgical in 5 cases, radiological in 2 cases.

<sup>1</sup> Lower part of antero-lateral aspect of thigh only.

Figure XX shows an area of sensory disturbance in a patient with a lesion of the fifth lumbar nerve. Head did not include the toes in the fifth lumbar dermatome, but recent experience would indicate that they may be included.

In searching the literature I have found no record of a case of *herpes zoster* affecting the fifth lumbar segment. I have had three surgically proved

cases of root pain involving a sixth lumbar nerve, the features being those of a fifth lumbar root pain, and one surgically proved case of root pain involving the first sacral nerve in a patient with four lumbar vertebrae, the features being those of a first sacral root pain. This is in agreement with the



FIGURE XVII. Hypoalgesia in a patient with a fourth lumbar root pain. (Author's case.)



FIGURE XVIII. Hypoalgesia in another patient with a fourth lumbar root pain. (Author's case.)



FIGURE XIX. Herpes zoster of the fourth lumbar segment. (Author's case.)

opinion of Begg, Falconer and McGeorge,<sup>(17)</sup> who find that the symptomatology of a lesion of the lowest lumbar disk is the same, irrespective of whether the patient has four, five or six lumbar vertebrae.

TABLE V.

Twenty-eight Cases of Fifth Lumbar Root Pain, Showing Numbers of Cases of Each Type of Disturbance.

Area.	Pain.	Tingling.	Numbness.	Hypo-aesthesia.	Hypo-algesia.
Posterior aspect of thigh .. ..	12	—	—	—	—
Postero-lateral aspect of thigh .. ..	10	—	—	—	—
Lateral aspect of thigh .. ..	6	—	—	—	—
Posterior aspect of leg .. ..	4	1	1	—	—
Postero-lateral aspect of leg .. ..	6	1	1	—	1
Lateral aspect of leg .. ..	11	2	2	1	4
Antero-lateral aspect of leg .. ..	6	1	2	7	8
Anterior aspect of leg .. ..	1	—	1	—	—
Lateral aspect of foot .. ..	2	—	—	1	4
Dorsum of foot .. ..	2	3	5	4	4
Antero-medial aspect of foot .. ..	1	1	1	1	2
First toe .. ..	4	5	8	6	7
Second toe .. ..	3	4	7	5	8
Third toe .. ..	—	2	4	3	6
Fourth toe .. ..	—	2	4	3	6
Fifth toe .. ..	—	2	3	2	5

Cramps in the calf, 1 case; weakness of dorsiflexion of the ankle, 1 case; weakness of dorsiflexion of the toes, 12 cases; weakness of dorsiflexion of the great toe only, 2 cases; paralysis of dorsiflexion of the ankle and toes, 1 case; weakness of plantar flexion of the ankle, 5 cases; weakness of plantar flexion of the toes, 2 cases; ankle jerk diminished in 13 cases and absent in 2 cases; plantar reflex absent in 1 case. Confirmation—surgical in 13 cases and radiological in 16 cases.

#### THE SACRAL DERMATOMES.

It must be remembered that Head investigated particularly the areas of cutaneous tenderness in visceral disease and tried to correlate these with

areas affected by herpes in order to work out the dermatomes. His reasoning in allocating various areas to the sacral dermatomes is difficult to follow; none of his sacral dermatomes was proved at autopsy and his first and second sacral dermatomes must be corrected.



FIGURE XX. Hypoesthesia and hypoalgesia in a patient with a fifth lumbar root pain. (Author's case.)

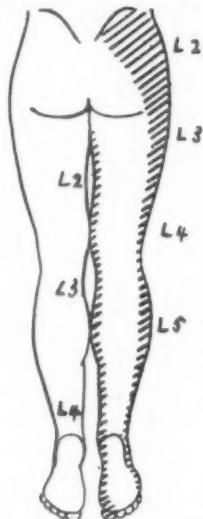


FIGURE XXI. The gap on the back of the lower limb which the sacral dermatomes occupy and overlap.

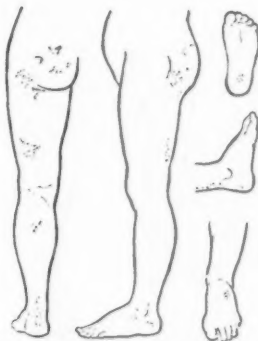


FIGURE XXII. Herpes zoster of the first sacral segment. (Head considered this was a herpes zoster of the first and second sacral segments.)

Between the third, fourth and fifth lumbar dermatomes laterally and the first, second, third and fourth lumbar dermatomes medially is an area of skin on the buttock, on the back of the thigh and leg, and on the sole and outer border of the foot, which the sacral dermatomes will occupy and overlap (Figure XXI). On anatomical grounds we would place the fourth sacral

TABLE VI.

Thirty-four Cases of First Sacral Root Pain, Showing Numbers of Cases of Each Type of Disturbance.

Area.	Pain.	Tingling.	Numbness.	Hypoesthesia.	Hypoalgesia.
Posterior aspect of the thigh .. ..	27	2	—	1	1
Postero-lateral aspect of thigh .. ..	7	2	2	—	2
Posterior aspect of leg .. ..	23	3	1	1	1
Postero-lateral aspect of leg .. ..	4	2	1	1	2
Lateral aspect of leg .. ..	6	3	1	2	10
Antero-lateral aspect of leg .. ..	1	—	—	—	—
Lateral aspect of foot .. ..	5	5	6	2	10
Dorsum of foot .. ..	1	1	1	—	1
Antero-medial aspect of foot .. ..	—	—	1	1	1
Heel .. ..	—	1	1	—	—
Sole .. ..	2	2	2	—	—
First toe .. ..	1	2	1	—	1
Second toe .. ..	—	3	1	—	4
Third toe .. ..	1	4	2	—	8
Fourth toe .. ..	1	5	3	1	10
Fifth toe .. ..	—	5	3	1	10

Cramps in the hamstrings, 2 cases; cramps in the calf, 3 cases; wasting of the buttock, 1 case; wasting of the calf, 1 case; fibrillary tremor in the buttock, 1 case; fibrillary tremor in the hamstrings, 2 cases; fibrillary tremor in the calf, 2 cases; weakness of dorsiflexion of the toes, 3 cases; weakness of dorsiflexion of the great toe only, 4 cases; weakness of plantar flexion of the ankle, 11 cases; ankle jerk diminished in 8 cases and absent in 18 cases. Confirmation—surgical in 21 cases and radiological in 13 cases. The pain was bilateral in 3 cases.

dermatome in a small area over the sacro-coccygeal region. The major portion of this gap will therefore be occupied by the first, second and third sacral dermatomes, and of these the first should lie laterally, the third medially, and the second should occupy an intermediate position.

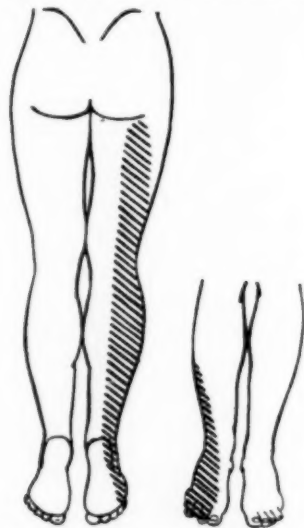


FIGURE XXIII. Hypoalgesia in a patient with a first sacral root pain. (Author's case.)

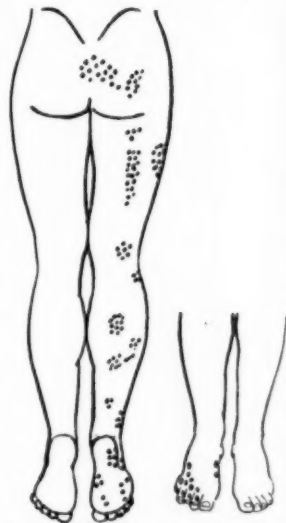


FIGURE XXIV. Herpes zoster of the first sacral segment. (Author's case.)

Head regarded Figure XXII as a herpes of the first and second sacral roots, the former supplying the area below the knee, the latter the area above it; but the first sacral nerve must innervate a greater area than Head has allotted to it, for it supplies a branch to the skin over the sacrum and



FIGURE XXV. Herpes zoster of the fourth sacral segment. The prepuce was also involved. (By courtesy of Dr. H. Macmillan.)



FIGURE XXVI. Herpes zoster of the third sacral segment. (Von Bärensprung's case X.)

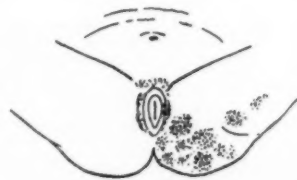


FIGURE XXVII. Herpes zoster of the third sacral segment. (Von Bärensprung's case X.)

buttock (Figure IV) and it innervates the skin of the back of the thigh through the posterior femoral cutaneous nerve. Today I think we would regard Figure XXI as an example of herpes of the first sacral root only.

First sacral root pain (Table VI) radiates to the postero-lateral part of the thigh and leg, to the lateral part of the foot and especially to the outer

toes. Sensory disturbances occur especially in the postero-lateral part of the leg, the lateral part of the foot and the outer toes. It is noteworthy that sensory disturbances may occur in the postero-lateral part of the thigh, sometimes a point of distinction from fourth and fifth lumbar root pains. There is often weakness of plantar flexion of the ankle, less often weakness of dorsiflexion of the toes. The ankle jerk is often absent, sometimes diminished or unaffected.

Figure XXIII shows an area of sensory loss in a patient with a lesion of the first sacral nerve.

Figure XXIV is drawn from natural colour photographs of a case of herpes seen by myself, and I think it involves the full extent of the first sacral dermatome.

Figure XXV is a case of herpes in a patient who was referred to me. It cannot be a herpes of the fifth sacral segment, for the fifth sacral nerve does not innervate the prepuce, which was also affected. On anatomical grounds it would seem certain that this is a case of herpes of the fourth sacral segment.

Figures XXVI and XXVII were published by von Bärensprung. Mackenzie regarded them as cases of *herpes zoster* of the fourth sacral segment, but Head and Campbell apparently thought they involved the third sacral segment. This opinion is undoubtedly correct, for the rash occupies the medial part of the gap shown in Figure XXI.

Figure XXVIII is a case of *herpes zoster* published by Mackenzie. The rash occupies a position intermediate between Figure XXIV on the one hand and Figures XXVI and XXVII on the other. I have no doubt that it is a case of *herpes zoster* involving the second sacral segment.



FIGURE XXVIII.  
*Herpes zoster* of the second sacral segment. (Mackenzie's case.)

#### THE DISTRIBUTION OF THE PAIN DERMATOMES IN MAN.

Figure XXIX represents what I believe to be the cutaneous distribution of the pain fibres of the posterior nerve fibres in man. It is not suggested that this figure is accurate—no figure can be until our knowledge is complete. Further work needs to be done on this subject, and in particular reports of cases of *herpes zoster* affecting the seventh and eighth cervical and the third, fourth and fifth lumbar roots should be published.

#### ACKNOWLEDGEMENTS.<sup>1</sup>

I am indebted to Professor R. D. Wright, Professor S. Sunderland, and Dr. E. R. Beech for help in the preparation of this paper, and to Dr. H. Macmillan, who referred to me cases of *herpes zoster*.

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- <sup>(5)</sup> H. Head: "On Disturbances of Sensation, with Especial Reference to the Pain of Visceral Disease", *Brain*, Volume xvi, 1893, page 1.

<sup>1</sup> Since this article was written, Guthaner (*British Medical Journal*, Volume I, 1948, page 521) has recorded a case of *herpes zoster* affecting the fifth lumbar dermatome. He informs me (personal communication) that the area affected was that shown in Figure XXIX and in addition the outer aspect of the knee and the outer aspect of the lower third of the thigh.

<sup>(6)</sup> H. Head: "On Disturbances of Sensation, with Especial Reference to the Pain of Visceral Disease. Part II: Head and Neck", *Brain*, Volume xvii, 1894, page 339.

<sup>(7)</sup> H. Head and A. W. Campbell: "The Pathology of Herpes Zoster and its Bearing on Sensory Localisation", *Brain*, Volume xxiii, 1900, page 353.

<sup>(8)</sup> O. Foerster: "The Dermatomes in Man", *Brain*, Volume lvi, 1933, page 1.

<sup>(9)</sup> W. J. Mixer and J. S. Barr: "Rupture of the Intervertebral Disc with Involvement of the Spinal Cord", *The New England Journal of Medicine*, Volume cxxi, 1934, page 210.

<sup>(10)</sup> H. Head: "Studies in Neurology", 1920.

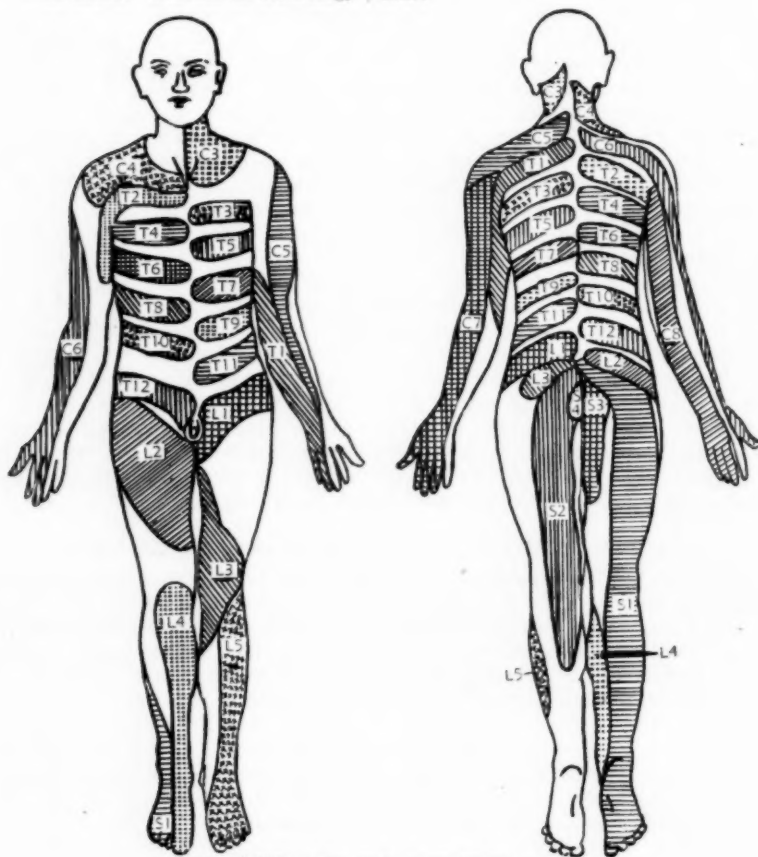


FIGURE XXIX. The pain dermatomes in man.

<sup>(11)</sup> J. J. Keegan: "Dermatome Hypalgesia with Posterolateral Herniation of Lower Cervical Intervertebral Disk", *Journal of Neurosurgery*, Volume iv, 1947, page 115.

<sup>(12)</sup> J. H. Young: "Cervical and Thoracic Intervertebral Disk Disease", *The Medical Journal of Australia*, Volume ii, 1946, page 833.

<sup>(13)</sup> Von Bärensprung: *Charité-Annalen*, 1861, Volume ix.

<sup>(14)</sup> J. Mackenzie: "Herpes Zoster and the Limb Plexuses of Nerves", *The Journal of Pathology and Bacteriology*, Volume i, 1893, page 332.

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<sup>(17)</sup> A. C. Begg, M. A. Falconer and M. McGeorge: "Myelography in Lumbar Intervertebral Disk Lesions: A Correlation with Operative Findings", *The British Journal of Surgery*, Volume xxxiv, 1946, page 14.



## EVENTRATION OF THE DIAPHRAGM: ITS IMPORTANCE IN DIAGNOSIS.<sup>1</sup>

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*Sydney.*

WITH NOTES ON PHRENIC EVULSION AND ITS RELATIONSHIP TO SYMPTOMS  
BY COTTER HARVEY,  
*Sydney.*

EVENTRATION of the diaphragm is brought about by an atrophy of its muscular fibres, probably due to a lesion in the phrenic nerve. As a rule the condition is unilateral and the nature of the nerve lesion is unknown. Rare bilateral and acute cases have been reported, for example, in patients with diphtheria, in which it may cause severe and dangerous respiratory distress. But in the usual unilateral case the onset is insidious and the patients remain symptom-free. When symptoms occur in unilateral cases it is sometimes difficult to evaluate their relationship to the eventration. The symptoms may be due to some other cause, for

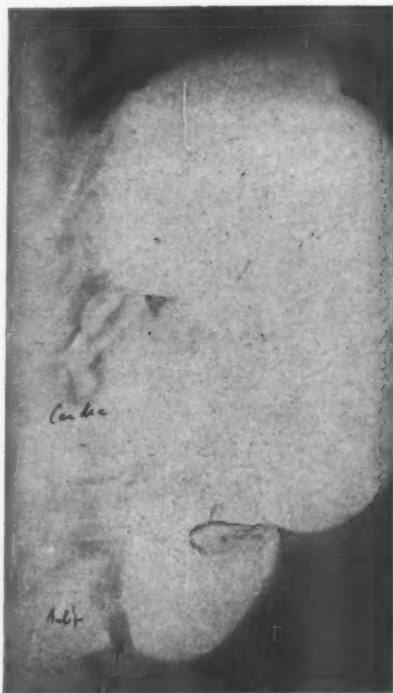


FIGURE I. Case I. Eventration of left lobe of diaphragm. Mistaken for diaphragmatic hernia.

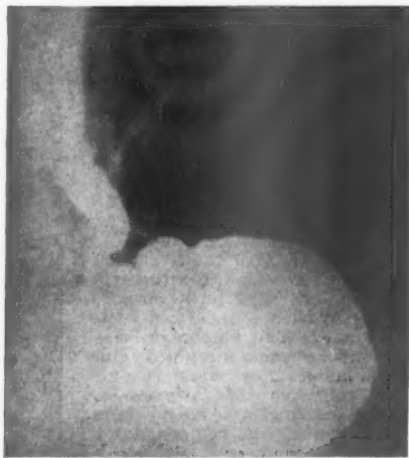


FIGURE II. Case I. Eventration of left lobe of diaphragm. Note level of barium in stomach, no higher than cardio-oesophageal orifice.

example, bronchitis or neurosis or coronary sclerosis. The experience of chest physicians with patients who have had a phrenic evulsion suggests that eventration is an unlikely cause of symptoms.

<sup>1</sup> Accepted for publication on September 2, 1948.



FIGURE III. Case II. Eventration of right lobe of diaphragm. Mistaken for hydatid cyst of liver.

symptoms are probably of neurotic origin.

CASE II.—Mrs. M.D., aged fifty-five years, referred by Dr. F. A. Lawes, complained of persistent cough. A skiagram of her chest showed a marked elevation of the right side of the diaphragm (Figures III and IV). Hydatid cyst of the liver was diagnosed, in spite of a negative response to the Casoni test. This test had recently given a negative result in the case of patients with proved hydatid disease, thus casting doubts upon the reliability of the available antigen. At operation the upper surface of the liver was explored by the transthoracic route and found to be normal. No hydatid cyst was discovered. The diaphragm was motionless and atrophied, and the muscle fibres were replaced by yellowish fibro-fatty tissue. The patient's convalescence was smooth and the cough disappeared spontaneously.

CASE III.—Mr. A.W., aged thirty-five years, had a diaphragmatic "hernia", so-called, of traumatic origin. This was really a rent in the diaphragm, with protrusion of abdominal contents into the pleural cavity. It was successfully

Eventration does not require treatment. It is therefore important, not so much for its own sake as for the necessity of distinguishing it from conditions which require operation. On the right side it may simulate hydatid disease of the liver, and on the left, diaphragmatic hernia.

CASE I.—Mr. A.G.L., aged fifty-four years, referred by Dr. S. F. Lynch, complained of indigestion and epigastric pain. The radiologist reported a diaphragmatic hernia on the left side (Figures I and II). I agreed with this diagnosis, performed a laparotomy and discovered that there was no hernia, but an eventration. Subsequently this patient remained under observation for some years. His symptoms persisted, but he continued at work and remained in good general condition. No other organic cause was discovered. His



FIGURE IV. Case II. Eventration of diaphragm. Lateral view.

repaired. His films are included (Figures V and VI) for comparison with those of the patient in Case I.

When an elevation or lesion of the diaphragm is discovered, further steps are necessary to establish the diagnosis, including a careful fluoroscopic study, as well as the preparation of skiagrams, special attention being paid to the following points.

Immobility or paradoxical movement of the affected half of the diaphragm in deep inspiration should help to distinguish eventration of the right half of the diaphragm from uncomplicated hydatid cyst of the liver. It would not be helpful if the cyst was infected and the diaphragm immobilized by inflammation; but in such cases a pleural effusion would probably



FIGURE V. Case III. Traumatic "hernia" of diaphragm. Note tied-string sign. The pylorus appears tied to the lower end of the esophagus.

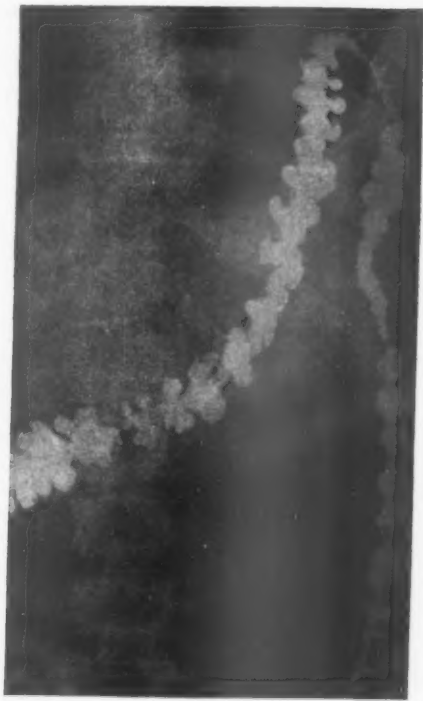


FIGURE VI. Case III. Traumatic "hernia" of diaphragm. Note the tied-string sign. The limbs of the splenic flexure appeared tied together.

exclude eventration. The test is not helpful on the left side because the abdominal viscera, when displaced into the pleural cavity, fail to descend on inspiration, just as they fail in eventration.

It has been suggested that the performance of the Valsalva test forces the affected half of the diaphragm downwards in eventration. I have had no experience of this.

On the left side other signs must be sought for, and these may be helpful on the right side in those rare cases in which the stomach or intestine passes into the right side of the thorax.

Sometimes it is possible to distinguish part of the diaphragm in its normal position at a lower level than the gas-filled stomach and intestines. Hernia may then be diagnosed.

In regard to the constriction sign, a barium-filled viscus may be seen to pass through a narrow orifice. A string appears to be tied around it and the part beyond the constriction becomes distended and lies in the thorax. The string may appear to be tied across the body of the stomach, or it may appear to tie the pylorus to the cardiac orifice (Figure V), or a loop of intestine, often the splenic flexure, may appear partially tied off (Figure VI).

With the patient in the upright position the highest level of the meal does not remain above the cardio-oesophageal junction in eventration (Figure II), but it may remain higher in hernia.

A pneumoperitoneum may occasionally help the diagnosis.

#### PHRENIC EVULSION AND ITS RELATIONSHIP TO SYMPTOMS (COTTER HARVEY).

1. Dr. Geoffrey Todd tells me that 30% to 40% of patients have a temporary gastric upset after left-sided phrenic crush; 2% to 3% have quite serious disturbance, but he cannot remember one case in which gastric symptoms have been permanent.

2. My private records accord with this. I have had no case with chronic gastric symptoms after phrenic crush.

3. Of 56 patients so treated at the Royal North Shore Hospital of Sydney one is recorded as having flatulence persistently after the operation. But as we have not been able to check whether this symptom was present before operation the case cannot be regarded as *post hoc*.

4. Dr. Bruce White recalls having seen many cases of eventration of the diaphragm amongst army recruits. All patients were questioned carefully and in no single instance was there any complaint of gastric symptoms. No doubt most of the recruits were anxious to join the army and thus would tend to discount symptoms; but service was compulsory and some would have confessed.

## CAUSALGIC SYNDROMES.<sup>1</sup>

By W. V. MACFARLANE,

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THE recent war has redirected attention to the painful after-effects of peripheral nerve trauma. Yet some of the less severe forms still pass unrecognized, even though knowledge of these conditions has grown with successive wars. Ambroise Paré encountered them during his service as surgeon with the kings of France in the wars against Italy and in the civil war with the Huguenots. In his civil practice Paré was called upon to treat the persistent crippling pain which followed Antoine Portail's bleeding of King Charles IX in 1564 for a smallpox fever (*Œuvres*, 1840). Denmark in 1813 likened a radial nerve injury with burning pain, hyperalgesia and trophic changes to *tic douloureux*, while Sir James Paget (1864) described similar features of painful, weak and glossy fingers after injury. But it was Silas Weir Mitchell (1864), a pupil of Claude Bernard, who first clearly defined a syndrome of this group of diseases. With the neurologist Moorehouse and the surgeon Keen, Mitchell studied the nerve injuries of the Unionists in the American Civil War. For the torturing, hot pain, increased by emotion, noise, touch or dryness, the increased sensitivity, and the trophic changes he coined the term "causalgia" (*καυω* = I burn). This precise and illuminating clinical work lay fallow till 1915, when the German invasion of France left a trail of causalgic casualties. These were investigated in 1915 by Pierre Marie and Madame Benisty (1918) of La Salpêtrière. They described the disease anew, ascribing it to arterial and sympathetic damage. René Leriche (1916) was already using periarterial sympathectomy for vascular spasm, so he was led to try his method in causalgic cases. He performed a periarterial sympathectomy on August 27, 1915, on the axillary artery of a soldier who had been wounded in the armpit and who was suicidal from causalgia. The soldier was relieved of pain; and at Strasbourg, Leriche, from this encouraging beginning, subsequently developed his ideas of the role of the sympathetic nerves in the syndrome. The 1914-1918 war casualties were studied also by Babinski and Froment (1918) in France and by the Medical Research Council of Britain (1920). The latter body minimized the importance of causalgia, though 108 cases were cited. Neurolysis, alcohol injection of the affected nerve and liniments were the suggested therapy.

During the period of peace White (1930) followed Wertheimer and Leriche in using local anæsthetic block of the paravertebral sympathetic chain for treatment of causalgia. Livingston (1943), too, used diagnostic procaine block, and in addition codified conceptions of the syndromes, expanding the categories to include *meralgia paræsthetica*, stump neuromata, phantom limbs and glomus tumours. Homans (1940) pointed out that the sequelæ of mild accidents should also be included in the grouping of causalgic syndromes and be classified as minor causalgias.

For the causalgic injuries of the 1939-45 war de Takats (1945) attempted a synthesis of observations and experiments, pointing out that various pain neurons may be involved, either dorsal root, ganglionic, spinal or cerebral. More satisfactory hypotheses have been advanced by Doupe (1944) and by

<sup>1</sup> Accepted for publication on August 16, 1948.

Nathan (1947), who suggest that at the level of nerve damage, sympathetic efferent impulses interact with and pass centrally along pain fibres. With Livingston they seem to be approaching a physiological explanation for some of the causalgias.

#### THEORETICAL CONSIDERATIONS.

Many attempts have been made to relate the slight organic lesions in nerves and soft tissues to the variety and severity of the clinical causalgic syndromes. Five types of pathological event must be accounted for:

(i) The sensory features consisting subjectively of pain, either burning, boring, shooting or aching in type, and objectively associated with hyperalgesia (increased sensitivity to painful stimuli), hyperpathia (distorted pain caused often by light stimulus), deep tenderness, and often with hypoaesthesia (decreased appreciation of pain stimuli). These features are usually distributed beyond the conventional boundaries of peripheral nerves.

(ii) The motor signs of weakness, incoordination and sometimes contracture which affect muscles throughout the whole limb besides muscles directly supplied by the injured nerve.

(iii) The trophic changes leading to atrophy of the skin, muscles, ligaments, bones and to stiffening of joints.

(iv) The sympathetic disturbance showing as warmth or coldness, redness or blueness, and dryness or sweating of the extremity.

(v) The psychological reactions of withdrawal, self-absorption and difficult conduct.

Parts of these sets of disturbances are present in all causalgic syndromes. Weir Mitchell's (1872) interpretation of his observations was that the atrophy of the skin increased sensory perception, causing pain, and that reflex motor and circulatory changes were set up in susceptible subjects by a neuritis ascending from the injured part of the nerve. Since inflammatory changes of the nerve actually do not occur, this suggestion does not explain the pathological process. White (1946) thinks it possible that scarring of nerves may lead, by local anoxia, to repetitive firing of pain fibres and thus to a steady sensation of pain.

In 1915 Marie and Benisty considered two mechanisms: either that injury to *vasa nervorum* might interfere with the nutrition of axons or else that a sympathetic neuritis might affect the responses of the corpuscles of Ruffini, Meissner and Pacini. This idea of an injury to sympathetic nerves was developed by Leriche (1939) into his hypothesis that the sympathetic nerves accompanying arteries were responsible for causalgia. "Causalgia", he maintained, "is the reaction of a susceptible temperament to nerve injury, with vasomotor and trophic changes brought about by the sympathetics." But the sympathetic theory does not explain the sensory and motor disturbances, nor does it account for cases unrelieved by sympathetic interruption. Further, the vasomotor and sudomotor activity may be either increased or decreased at different times in the same case, and this suggests that the sympathetic factor is secondary to some other mechanism.

Another aspect of the problem was considered by Lewis (1936) in his study of noxious stimuli to skin. He suggested that hyperalgesia and burning pain might be due to antidromic impulses arising in a focus of nerve injury, liberating a pain substance in the skin which was perceived by other nerves in their territory of overlap. Pool and Brabazon (1945) give some support to this view in that they have shown that stimulation of the distal cut end of a nerve causes pain which is mediated by impulses passing up neighbouring intact nerves. The vasodilator theory was further elaborated by de Takats



(1945). He maintained that the syndromes were due to cholinergic substances reflexly liberated from sensory fibres. But though this might explain the vasodilatation, hot pain and hyperpathia, it does not account for the cold, blue and aching limbs that are often encountered at some stage of the causalgic syndrome, nor for the motor and atrophic changes.

A more comprehensive approach to the question was made by Livingston (1938 and 1943). He sought to explain the variable and widespread manifestations of these syndromes by a vicious cycle of nerve impulses set up within the spinal cord by an injured nerve or peripheral irritable focus. Peripheral irritation might, he argued, lead to facilitation and cyclic repetitive discharge of internuncial neurons of the spinal cord grey matter. A similar hypothesis is attributed to Charcot (1886) (cited by Adson and Rowntree, 1930). Charcot held that a peripheral focus produced a modified behaviour of the cord, which sent impulses down motor and sympathetic fibres to produce pain, wasting and vasomotor changes. The concept of neuron pools in the cord developed by Sherrington (1932) and by Gasser (1937) to explain normal reflex integrations can be fitted into the Livingston-Charcot hypothesis. Spread of the pathologically excited state of the cord neurons could produce by relays to neighbouring cells either excitation or inhibition of motor, sensory and sympathetic neurons, and in this way lead also to a steady stream of pain impulses to the cortex. Interruption of some part of the cycle on the afferent, sympathetic or central sides might be expected to relieve the causalgia. This hypothesis receives support from the fact that success in treatment has resulted from such diverse procedures as procaine blocks of scars and nerve trunks, sympathetic interruptions, posterior rhizotomy and from section of the spinothalamic tracts. Closely in agreement with Livingston's hypothesis are the observations on central pain made by clinical neurologists (Riddoch, 1938). Some lesions of the mid-brain and cord produce causalgia-like features, such as burning and aching pains in the extremities, hyperpathia, deep muscle pain and widely distributed hypoalgesia. These central pain syndromes are attributed to faulty inhibition and selection of impulses arriving in the thalamus. Dusser de Barenne's work (1912) on the application of strychnine to the spinal cord fits in at this point, for he showed that pain and hyperpathia followed the stimulation of the dorsal grey matter. Although the evidence is not direct, there is thus a close analogy between central irritative states and causalgia. The analogy may be converted to identity before long.

Some neurophysiological experiments give clues to the peripheral side of the possible vicious cycle. Porter and Taylor (1945) showed that painful stimuli applied over several hours to the sciatic nerve facilitated the stretch reflex responses of the spinal cord. Katz and Schmitt (1940) and the Stockholm workers Granit and Skoglund (1946) suggest that impulses passing down efferent nerve fibres may cross at an injured region from one nerve fibre to another and then pass up somatic sensory fibres to the cord, eventually producing pain.

A theory built on fibre-interaction has been elaborated by Doupe, Cullen and Chance (1944) and by Nathan (1947), who consider that efferent sympathetic impulses interact on sensory fibres at a focus of nerve damage and that these relay centrally, causing the constant pain. This theory would account for the effect of blocking or excision of the sympathetic chain, but it does not explain cases of causalgia in which the injury is intrathecal and thus proximal to the usual sympathetic inflow, nor the cases unrelieved by sympathetic interruption.

Mitchell, Leriche and Livingston have all stressed the emotional disturbances accompanying causalgia. Riddoch describes similar states in

thalamic and cord injury syndromes. The observation that emotion (fear or anger) may increase causalgic pain is held by Doupe, Cullen and Chance (1944) to be due to the vasomotor and sudomotor impulses that accompany emotion, interacting on sensory fibres, which relay impulses back to the cord and brain, where they are recorded as pain. The irascibility, withdrawal, misery, sleeplessness and hostility of the causalgic patient have frequently been assumed to be psychoneurotic. The reappearance of a seemingly normal personality, which at once accompanies the relief of causalgia by a successful blocking of the sympathetic chain, casts doubt on any assumption of a primary psychoneurosis. Yet Lidz and Payne (1945) report a case of apparent true causalgia with objective signs, in which the patient's disability was removed on relief of acute anxiety.

The observation that frontal lobotomy reduces the emotional responses to pain (Falconer, 1948) provides further evidence that the higher centres may modify the acuteness of reaction to causalgia. We have been impressed by the lack of neurosis of our patients. They may be miserable and greatly concerned with their symptoms and with failures of treatment, but they have surprisingly little psychoneurosis interwoven with their organic disease.

Looked at broadly, it seems that Livingston's hypothesis best fits the clinical observations, with perhaps fibre-interaction accounting for the impulses which build up the excitation of the cord neurons. This, however, has still to be proved.

#### CLASSIFICATION OF SYNDROMES.

The main group of nerve injury pains has been variously categorized so that there is a good deal of confusing synonymy. Leriche (1939) lists (a) causalgia (burning pain), (b) post-traumatic spreading neuralgia (slight injury with spreading pain and weakness), (c) painful neuromata and scars, (d) amputation stump pains and phantoms. He does not distinguish the minor causalgias of Homans nor the types in which burning pain is not evident.

Livingston's revised classification (1943) was: (a) causalgia (burning pain after severe nerve trauma); (b) minor causalgia (slight injury, not necessarily to nerve, with burning pain); (c) post-traumatic pain syndromes (slight injury without burning pain); (d) reflex pains (from foci in muscles).

The groups of Leriche and Livingston are a mixture of pathological and symptomatic categories, and there are often wide overlaps from one group to another. The burning causalgias, for example, usually have a stage when aching pain may predominate, and many stump pains and minor causalgias are associated with painful neuromata. Some of the minor causalgias (Homans, 1940) correspond to Leriche's spreading neuralgia and de Takats's (1945) reflex dystrophy. Livingston's post-traumatic pains are very similar to this group of minor causalgias, except that the burning pain is replaced by an ache.

Doupe, Cullen and Chance (1944) make the following classes:

- (i) Psychogenic causalgia (aching pain without neurological signs).
- (ii) Causalgia (burning pain after nerve injury): (a) proximal fibre interaction, (b) distal fibre interaction.
- (iii) Dystrophic pain (aching pain and œdema, following nerve injury or fractures).

This is an attempt at aetiological classification. It rests, however, upon unproven hypotheses. Moreover, we feel that the "dystrophic" type of pain really merges with the "causalgic" pains "due to distal fibre interaction" (that is, minor causalgia). Psychogenic pain without signs can hardly be considered a causalgia.

It seems that here are a number of conditions which have a common neurological basis and which should be grouped together. A consistent symptomatic classification can be made if regard is taken of the common elements of the pain syndromes, such as persistent pain, hyperpathia, hypoalgesia, sympathetic and trophic changes, and the frequent relief following sympathetic interruption. Since "causalgia" denotes "burning pain" from its etymology, it seems better to replace it by a more general generic name, such as "post-traumatic pain states". Clinically the following gradations are easily recognized:

*Post-Traumatic Pain States:*

- (i) Major causalgia (widespread peripheral pain after a nerve injury): (a) burning type (classical Weir Mitchell syndrome), (b) mixed type (burning and aching together or in sequence), (c) aching type (no burning pain, but often surging or shooting pains).
- (ii) Minor causalgia (peripheral pain of lesser degree and extent after bruises, cuts or crushes): (a) burning type, (b) mixed type, (c) aching type.
- (iii) Amputation stump pains: (a) in the stump alone (causalgic stump), (b) in both stump and phantom limb, (c) in phantom alone.
- (iv) Miscellaneous conditions in which probable nerve injury is produced without external trauma: *meralgia paraesthetica*, Sudeck's bone atrophy, painful types of Volkmann's contracture, thrombophlebitis and arterial spasm (some cases), glomus tumour, myositis and fibrositis (some cases), painful arthritis (some cases).

CLINICAL OBSERVATIONS.

In the course of two years (1945 and 1946) 21 cases of post-traumatic dysaesthesia were investigated and treated in the Department of Neurosurgery at the Dunedin Hospital.

*Major Causalgia.*

Causalgia in the classical sense occurred in 13 patients, the pain ranging from burning to aching with gradations in between. The most noteworthy difference between this series and the usual findings in reported cases were the uncommon sites of the pain, the transition of one type of pain to another, and the frequent resistance of the pain to sympathetic interruption. Of the 13 patients, five had injuries either to intrathecal nerve roots or to nerve trunks close to the vertebral column, two had median nerve injuries, and six had injuries which involved the sciatic trunk. The types of injury varied from gunshot wounds (nine cases), sequelae of operative explorations (hip fusion, one case; removal of prolapsed intervertebral discs, two cases), to one stab wound.

The main features of the three groups of major causalgia may be seen in Table I. The cases are arranged to show a gradation from one type to the next.

*Burning Pain.*—Burning pain predominated in three patients who suffered from a classical Weir Mitchell causalgia. The injuries were all to nerve roots or to primary rami near the vertebral column. Burning unremittent pain, severe hyperpathia, heat intolerance, excessive sweating and maceration of the atrophic skin with weakness of muscles, stiffness of joints and osteoporosis were characteristic of these patients. They all showed emotional disturbance, withdrew to themselves and were both frightened and resentful. One had developed an habitual torticollis in guarding his affected shoulder from stimulation. He illustrates the syndrome.

CASE II.—A soldier of twenty-two years received a mortar fragment wound in the region of the transverse processes of the fifth and sixth cervical vertebrae on the

left side. The wound was excised three days later and at once burning pain came on in the arm down its outer side. The shoulder was hypersensitive, so that he could not tolerate anything other than silk near it, and the stinging, burning pain was constantly present, interfering with eating and sleeping. His head became twisted over towards the affected shoulder to protect it. He was unable to wash the painful area and a greasy acne developed there.

When examined one year after wounding he exhibited severe hyperalgesia over the fourth cervical segmental area and a lesser hypersensitivity over the fifth cervical area extending down to the elbow level laterally. Although the skin showed the local

TABLE I.

*Symptoms and Signs in Thirteen Cases of Major Causalgia Arranged in Groups to Show Transitions from One Group of Case to the Next.*

	Case Number.	Site.	Burning.	Aching.	Hyperpathia.	Hypoaesthesia.	Tender Spots.	Tender Muscles.	Excess Sweating.	Macerated skin.	Unsuccessful Procedures.	Useful Procedures. <sup>1</sup>
Burning	I	C <sub>4</sub>	++	—	+++	—	—	—	+	+		BL
	II	C <sub>4</sub>	+++	—	+++	—	—	—	+	+		RH
	III	C <sub>4</sub> Cauda	+++	±	+++	+	—	+	+	+	RH, SY	RH CH
Mixed	IV	Sci	+	+	+	+	+	+	±	—	SY	BL
	V	Sci	+	+	+	+	+	+	—	—		CH
	VI	Sci	+	+	+	+	+	+	—	—		BL
	VII	Sci	+	+	+	+	+	+	—	—	SY, TR	NE
	VIII	Sci	+	++	+	+	+	+	—	—		CH
	IX	Cauda	○	++	+	+	+	+	—	—	SY	CH
	X	Med	++	++	+	+	—	—	—	—		NE
	XI	Med	++	+	+	+	—	—	—	—		
	XII	Cauda	○	++	+	+	—	—	—	—	RH	CH
	XIII	Sci	—	++	+	+	—	+	—	—		CH

± weakly present.  
+ present.  
++ severe.  
○ transitory.  
— absent.

<sup>1</sup> BL = procaine infiltration of sympathetic chain.  
NE = neurolysis.  
RH = posterior rhizotomy.  
SY = preganglionic sympathectomy.  
CH = antero-lateral chordotomy.

acne, it was not atrophic, sweaty or mottled. Wasting and weakness of the shoulder girdle muscles were present, and a marked torticollis to the left side resisted all attempts to straighten his neck (Figures 1a and 1b). Mentally he was apprehensive, quiet and retiring in a resigned fashion. Although he had previously been treated as a psychiatric casualty, there was no obvious psychoneurosis.

As sympathetic block gave no relief, paravertebral infiltration of the brachial plexus with procaine was then tried. This relieved the pain and hyperpathia temporarily, and therefore posterior rhizotomy of the fourth and fifth cervical nerves was carried out. This procedure abolished his pain, the hyperpathia being replaced by anaesthesia. To correct the torticollis a plaster jacket had to be applied for six months. Relief has persisted for one and a half years and the patient is usefully employed.

As a group these patients were difficult to manage, both because of the pain and because of the emotional disturbance. Not one of them, however, demanded the traditional continuous cold bathing of his limb. Further noteworthy features were the absence of localized tender spots in the muscles and the prevalence of excessive sweating. In one case (Case III) the whole limb was exquisitely tender to touch, and this symptom was removed temporarily by sympathetic block. Sympathectomy, however, gave only transient relief.

*Mixed Aching and Burning Pain.*—Mixed aching and burning pain occurred in nine patients. In seven, peripheral nerves were involved (sciatic five cases, median two cases) and in two, nerve-root lesions had occurred (both *cauda equina*). The early stages of these causalgias were dominated by burning pain, which reached its maximum within three months of the injury. Gradually this was replaced by lancinating and aching pains, with

only slight and intermittent burning qualities. There was thus a serial development shown by the pain.

The other differential features of the group were the absence of any notable sweating and maceration of the skin. The limbs and extremities involved were cold rather than hot, and there was no heat intolerance. Nearly all patients showed exaggerated tenderness of the muscles with local



FIGURE 1A. Case II. Gunshot injury in the region of the fifth cervical spine. Zones of hyperpathia are marked in, the zone of great severity being inside the less severe zone. The fourth and fifth cervical roots are involved.



FIGURE 1B. Case II. Gunshot injury in the region of the fifth cervical spine. Zones of hyperpathia are marked in, the zone of great severity being inside the less severe zone. The fourth and fifth cervical roots are involved. Note the torticollis and the protected left arm.

areas of great sensitivity to pressure. These tender spots were associated usually with strips of hyperalgesia. Injection of procaine into the spots abolished local tenderness and the local hyperalgesia, and relieved some of the aching pain. The legs were involved in all but two of these cases, and Cases IV and IX illustrated the conditions found.

CASE IV.—A soldier, aged twenty-three years, was wounded in the thigh by gunfire. At operation slight contusion of the sciatic nerve was found. Two weeks later he developed a burning pain in the foot, which reached its greatest intensity after five weeks. Simultaneously, sharp, shooting pains troubled him in the thigh, at first constantly but later intermittently. After eighteen months, when he came to our notice, there was a burning pain in the instep, with aching and shooting pain in the calf and hyperpathia of the sole and part of the dorsum of the foot. Examination disclosed a tender spot near the head of the fibula with a hyperalgesic strip four centimetres wide extending down to the heel, hypoaesthesia antero-laterally over the lower leg, and analgesia on the outer border of the foot. There was little wasting of the skin or muscles, but the leg was weak and extensive osteoporosis of the foot bones was shown by X rays. In addition, a painful *hallux rigidus* was present. Five infiltrations of the lumbar sympathetic chain with procaine solution were carried out with successively greater relief from pain and hyperpathia after each injection. When discharged from hospital he was able to walk well, but with some disability from a now painless *hallux rigidus* and a contracture of the gastrocnemius muscle. Two years later he remains in comfort and gainful occupation.

CASE IX.—A soldier, aged twenty-two years, was wounded at Cassino by a bullet which traversed the *cauda equina* at the third lumbar level and produced a partial



lesion involving the left side more than the right. Eight hours after being wounded, when the extensive initial numbness had worn off, he complained of burning pain in both feet and calves. Following excision of the wound this pain was relieved, but three weeks later the soles of both feet experienced pain like that of a flame applied to the skin. This gradually moderated and localized to the bases of the toes of the left foot. Then six months after injury a surging and shooting pain developed medially in the left leg and on the dorsum of the foot. The burning and surging persisted, but were not incapacitating when he came to us fifteen months after injury. He then showed weakness and wasting of the leg, some skin and bone atrophy, anaesthesia of approximately the second and third sacral segments, hypoaesthesia of much of the back of the leg (fourth lumbar and first sacral segmental zones), and hyperpathic responses

on the sole (Figure II). All the leg muscles were tender to deep pressure. There was excessive sweating but no heat intolerance.

Since local infiltration of the lumbar sympathetic chain stopped the pain temporarily, a sympathectomy was carried out (excision of the third and fourth lumbar ganglia). This produced anhidrosis of the left leg below the groin (quinazarin sweating test), but his pain was unchanged. Subsequently antero-lateral chordotomy at the sixth thoracic level relieved both types of pain in his leg, and since then he has remained comfortable for one and a half years.

These examples indicate the changing character of pain met with in this group. The patients were not psychologically abnormal and they were not in acute misery. They showed a sensible fortitude in tolerating bursts of pain daily for many months with little deterioration of their morale.

**Aching Pain.**—Aching pain was the main complaint in one case.

**CASE XII.**—In this patient a tight pain in the lower leg and sole of the foot followed a bullet wound in the buttock. The patient was a married woman of thirty-one years, who said that three weeks after the injury the foot became hypersensitive to touch and felt as though it were encased in a tightening rope. Examination showed a partial sensory and motor lesion of the sciatic nerve with patchy hypoaesthesia and with wasting of most muscles of the leg. The muscles were tender to touch. Five

FIGURE II. Case IX. *Cauda equina* injury, showing zones of hypoaesthesia (widely spaced dots) with loss of hair, analgesia (closely spaced dots) and hyperpathia (crosses).

months after the injury (after failure of both a neurolysis of the sciatic nerve and a procaine block of the sympathetic chain) a chordotomy at the third thoracic level was performed with relief of the pain.

In this case there was no sign of sudomotor or vasomotor disturbance nor of tender spots. The skin looked almost normal, though rather dry. The aching pain was of great intensity and constant, whereas hyperpathia was not marked.

**Comment.**—Within the category of major causalgia we have thus met all gradations from the burning pain of the first group associated with sweating and hyperpathia to the dry aching limbs of the last group. The fact that transitions in signs and symptoms may occur within the same patient makes it likely that these variants are all part of the same syndrome. There is a danger that because there is no burning element some cases of the aching type may be classed as idiopathic neuritis and the disability consequently minimized. The strict Weir Mitchell concept of causalgia, with its emphasis on burning and sweating, is not adequate to cover the range of conditions,



and (if the varieties are not appreciated) timely therapeutic action on the sympathetic chain may be neglected till the causalgia is too firmly fixed to respond.

#### *Minor Causalgia.*

Homans (1940) in his category of minor causalgias included painful sequelae of infected wounds, crushes, fractures and muscular lesions in the extremities. The pain was not usually of a burning type, but rather a persistent ache with paræsthesiæ. The limb was either blue and cold or warm and pink, with some skin atrophy and weakness of neighbouring muscles. Osteoporosis and swelling of joints were noted. Hypoalgesia of irregular distribution with hyperalgesia localized in the painful area was always present.

The five cases of minor causalgia encountered were fairly typical. In one the pain followed a cut in the forehead over the supratrochlear nerve; in another a blow over the deltoid region, a crushed hallux in the third; and in two cases infected fingers led to the causalgia. Only two patients had some burning pain, but all five suffered either a steady ache or shooting pains in the affected area. The onset of pain was delayed one to twelve weeks from the time of injury, and in three cases it followed operative procedures. All five patients had especially tender spots in the tissues alongside the lesions.

The patient with the deltoid injury had complained of aching pain for three years and his arm was weak and wasted. An area of hypoalgesia existed on the outer aspect of the upper arm and was associated with two tender spots deep in the deltoid muscle. Infiltration of these spots on successive days with a local anæsthetic agent relieved both this pain and the hypoalgesia, and he was then able to raise his hand above his head (where it had not been for three years) while lifting a thirty-pound weight. The treatment has remained effective.

In the instance of the injured forehead the patient showed an hysterical personality, but the pain, of a tight prickling type, seemed organic, for it was distributed in the territory of the supratrochlear nerve and was associated with moderate hyperpathia. Resection and avulsion of the supratrochlear and supraorbital nerves relieved the pain. In the three cases in which digits were involved the affected area was mottled and cold, with shiny skin indicating atrophy. Weakness extended from the site of injury in the digit upwards to at least the knee or elbow, and similarly slight sensory loss was detectable above the wrist or ankle. Hyperalgesia, with its concomitant guarding of the digit, was present in all, but it was localized near the injury rather than widespread.

These minor causalgias responded well to interruption of the sympathetic nerves. Hyperalgesia and hypoalgesia disappeared instantly and power increased markedly as soon as block or resection was accomplished. In one case, however, the improvement was only transitory.

This patient was a man of fifty-three years, who developed an infection of the thumb pulp with a throbbing ache which troubled him constantly for five months. Before we saw him his thumb had been amputated at the interphalangeal joint in an attempt to relieve pain. Causalgic pain, weakness, hypoalgesia, hyperpathia and cyanosis developed in the stump and spread up the forearm. Temporary relief came from sympathetic infiltration, but a preganglionic sympathectomy (Smithwick type) gave only partial alleviation and was followed by new pains higher up in the arm. Loss of sweating over face, upper part of the thorax and arm testified to the completeness of the sympathetic interruption. The noteworthy feature of this case was the persistence of pain after amputation of the digit.

Leriche (1939) long ago pointed out the uselessness of amputations for the relief of causalgia pain. Another patient who came to us with a phantom limb syndrome illustrates this well.

In 1931, at the age of twenty-two years, she suffered a slight hand injury and a "spreading neuralgia" (Leriche) came on within three days. This minor causalgia caused cyanosis, sweating, pain and weakness to develop in the hand. Periarterial sympathectomy failed to give permanent relief so forearm amputation was resorted to. This led to phantom limb pain in the hand, which was not relieved by sympathectomy, even though a marked Horner's syndrome developed. An extensive posterior rhizotomy of the fourth cervical to the second thoracic segment numbed the stump and altered

the phantom, but did not abolish its pain. Finally, in 1947, chordotomy at a high cervical level brought some lessening of discomfort.

*Comment.*—The minor causalgias are a heterogeneous group, yet they show in common steady pain, hyperpathia, hypoalgesia, vasomotor changes and muscular weakness. These signs may not be obvious, but they should be sought for whenever a patient complains of an injury remaining troublesome months after it should have recovered. Three of our patients had been treated for some months as probable malingerers.

#### Stump Pains.

Pains in amputation stumps are often grouped with minor causalgia, yet there are all variations of

syndrome from painful stumps without phantoms to painful stumps with painless phantoms, then to painful phantoms with pain in the stump, and finally to phantom pain only. These painful conditions are all causalgic in type and it seems useful to look at them as a unit. In this paper, however, painful phantoms will not be considered, as a report on them has already appeared from this unit (Falconer and Lindsay, 1946).

We encountered two cases of pain following amputation in which there was no complaint of phantom phenomena, but mainly a stump sensitivity.

In one case, that of a soldier of twenty-three, shell fragments had blown away the fingers on his left hand nine months before he came for advice (Figure III). On being wounded he had immediately felt a throbbing ache in the hand, together with a sense of pressure. These pains were worst in the first two weeks, but they had remained constantly with him, preventing sleep. There were no burning or shooting pains, but often the ache extended up to his elbow. The distal half of his hand was hypoalgesic, except at the site of amputation, where there was a zone of acute hyperpathia (two centimetres wide). The skin was thin, and there were three deep, tender spots in the scar tissue. The scars were livid and cold. An upper thoracic sympathetic block gave prolonged relief from the aching pain, but the hyperpathia and local tenderness persisted. These residues were abolished by local infiltration of the tender spots, a painful procedure, but one followed by six months' relief. The aching pain and hyperpathia then returned also, and after an ineffective plastic repair of the scars the patient was submitted to a preganglionic sympathectomy of the upper thoracic region. The sequel of this operation was the development of well-marked phantom fingers with aching pain behind the phantom knuckles, and the hyperpathia and tender spots on his scars were not relieved, though the throbbing ache of his hand was lessened. In addition, the procedure produced a painful hyperpathic zone in the second thoracic segment distribution, although that root had been sectioned at operation. His pain still persists, but he is bearing it.

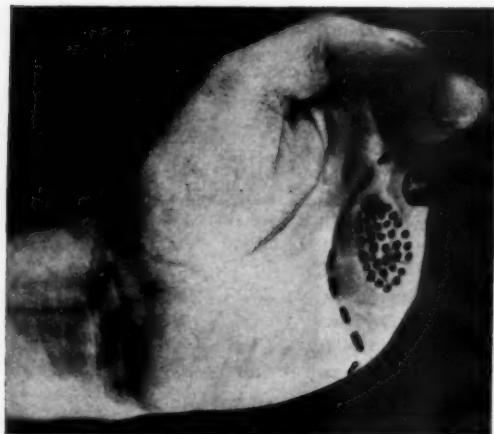


FIGURE III. Mortar wound of the hand. The large black area was acutely tender to pressure and when it was infiltrated with procaine, during sympathetic blockade, the zone of hyperpathia, indicated by the line of dashes, disappeared. The small palmar tender spot (black area) remained, however, with its dotted zone of hyperpathia. Infiltration of this second tender spot removed the smaller hyperpathic zone for six months.

In the other case a woman of fifty with a deforming disease of bone had had some useless phalanges removed from her hand elsewhere. Five days after the amputation a burning pain commenced in the ends of the finger stumps and aching pains extended up to her elbow. The tips of her fingers remained as painless phantoms. The stumps were hypersensitive to touch, but were subjectively numb. The skin was bluish, cold and damp. After a reamputation failed to give relief she suffered from hyperpathia of the stumps, burning pain, aches passing up to the wrist and paræsthesiæ in the knuckles. There was a tender spot on the stump of the medius, but it was not palpably a neuroma. Sympathetic block did not modify the pain, though the hand warmed 11° C. and a marked Horner's syndrome developed. Local infiltration around the ulnar and median nerves relieved the pain and hyperpathia temporarily. Accordingly resection of cutaneous nerves supplying the area of causalgia was undertaken with relief, but some burning pain then developed in the skin adjacent to the anæsthetic areas. Further measures seem unjustified, but the phantoms remained.

*Comment.*—The interest of these conditions is the link they provide with the painful phantom limbs, which should be classed with the post-traumatic pain states. The stumps were affected with minor causalgia, and in the first case a sympathectomy which failed to relieve the pain served to bring the phantom fingers to consciousness.

#### TREATMENT OF CAUSALGIC SYNDROMES.

Our method of attack in the treatment of causalgic syndromes has been directed towards ascertaining the level in the pain-conduction pathways at which section would lead to relief of pain. Working from the periphery, we have infiltrated local anæsthetic solutions in turn into painful scars, tender subcutaneous and intramuscular spots, sites of nerve injury, the ganglionated sympathetic chain, nerve trunks and roots proximal to the site of injury, and the lower part of the spinal cord. This has been our sequence in most cases, and if the peripheral injection failed we have gone on to the next more proximal injection. Thus if local blocks succeeded, then such local procedures as excision of a scar, neurolysis or resection of intraneural neuromata with end-to-end suture might be considered. If the sympathetic block succeeded, then sympathectomy was indicated. If this failed but nerve block proximal to the site of injury succeeded, then posterior rhizotomy was considered, although for practical purposes this operation is applicable only to cases in which division of one or two nerve roots would suffice, as in the trunk. When all of a major plexus is involved, as in either the upper or the lower limb, posterior rhizotomy is impracticable, because the sensory loss resulting from division of many posterior nerve roots would leave the limb useless; antero-lateral chordotomy is indicated instead. Finally, if in the lower limb spinal anæsthesia succeeded where peripheral and sympathetic injections had failed, an antero-lateral chordotomy was undertaken. As regards the upper limb, spinal anæsthesia is of course not feasible, and then a high cervical chordotomy has to be considered on its theoretical merits.

Procaine blocks of various types were employed in 20 of the 21 cases. In five of these persistent and apparently permanent relief of pain followed the infiltration. In 13 cases procaine block relieved pain for a few hours, and subsequently the indicated surgical procedure gave persistent benefit in seven, transitory benefit in five, and no relief in one case. (In this last case a differently located block gave a reliable forecast of the second surgical result.) In the remaining two cases no benefit followed sympathetic block, but the indicated chordotomies proved effective. Thus diagnostic procaine block by itself was adequate therapy in 25% of the group, and in the remainder it gave a correct prediction of the immediate surgical result in 93% and of the permanent result in 60%.

<sup>1</sup> Relief is defined as alleviation of pain sufficiently to allow patients to carry on their normal occupations. The degrees of relief have been divided into transitory (less than three months) and persistent (of more than three months' duration).

Local infiltrations of scars and tender areas were useful in five instances. One result, which was permanent, followed infiltration of acutely tender spots in the deltoid muscle.

In the other four major causalgias extensive zones of hyperpathia and hypoaesthesia were reduced or removed as the result of infiltration of tender spots in the muscles. In all five a prior sympathetic block had been ineffective. There was thus in these cases a local dependence of hyperpathia on the tender spots, independently of any central mechanism that could be relieved by sympathetic interruption.

Paravertebral block of the sympathetic chain by Labat's method was employed in 15 cases, using skin thermocouples to determine the vasomotor effects. Drying of the skin and Horner's syndrome were noted as additional checks on the degree of blocking. In four of the 15 cases in which block was used relapse has not occurred in eighteen months and one lasted six months. These included two major causalgias of the sciatic nerve of more than a year's duration, one major causalgia of the arm and one minor causalgia. Three to five infiltrations were given in each case, and these successively reduced symptoms until the patients were able to work with little disability. Rasmussen and Freedman (1946) report comparable findings (9% of a total of 91 patients). They obtained their best results in the early stages of the disease.<sup>1</sup>

Nerve trunks were blocked in 10 cases, and in two of these the transitory relief afforded indicated rhizotomy and neurotomy respectively. These surgical procedures were beneficial. In the remainder the results gave no positive indications.

Intrathecal use of procaine was employed diagnostically in three cases as a preliminary to possible chordotomy for lower limb conditions. The temporary paralysis of the lower cord segments was found to be a reliable index of the subsequent effects of chordotomy. In no instance, however, did any lasting therapeutic effect result from spinal anaesthesia, in contrast with the effects of peripheral nerve and sympathetic block. No attempts at intrathecal alcohol injection have been made because of the risk to sphincters.

#### *Surgical Procedures.*

With the results of procaine block as a guide various surgical interventions were undertaken.

The indication for local exploration of a nerve at the site of injury is relief of pain by procaine blocking in that region. Local procedures include neurolysis and nerve section. In two cases in this series in which nerve damage was slight, neurolysis was undertaken. One patient who had a sciatic causalgia, was not benefited, whereas the other, also suffering from a sciatic causalgia, was persistently relieved even though three previous chordotomies had each failed to give more than three months' relief.

Nerve suture after resection of the damaged area was undertaken in our series in only one instance (a partial median nerve lesion with neuroma) and with favourable results. It has been widely employed by several surgeons and was recommended by the Medical Research Council (1920). Indeed, Zikeyev (1946), who used six days' narcosis in addition, reports 31 out of 37 patients relieved by this method.

Neurotomy without suture is not often indicated and we employed it in only two cases. It was useful in one, a minor causalgia of the forehead, in

<sup>1</sup> The intramuscular or intravenous use of tetramethyl (or ethyl) ammonium bromide in order to paralyse transmission through sympathetic ganglia is comparable with the effect of procaine blocks. "T.E.A.B." has been employed in this unit in a recent case of minor causalgia of short duration and has given satisfactory relief. The substance was not available for trial during 1945-1946.

which avulsion of the supratrochlear nerve was effective. But in a case of stump pain, neurotomy relieved the pain already present, but renewed burning appeared at the margins of the anæsthetic area. Limiting factors to the use of neurotomy are the sensory and motor paralyses it produces and the difficulty of preventing regeneration.

When temporary release from pain follows blocking of nerve trunks or roots, posterior rhizotomy may be considered. This procedure has been condemned by Leriche (1939) and by de Takats (1946) as unsatisfactory and liable to produce *anæsthesia dolorosa*. It is therefore interesting that one patient with classical causalgia involving the fourth and fifth cervical nerves (Case II) was permanently relieved by posterior rhizotomy, indicated by a

TABLE II.

Results of Treatment. Distribution and Effectiveness of Procedures Employed.

Condition.	Local Infiltration.	Amputation.	Neurolysis and Resection.	Neurotomy.	Posterior Rhizotomy.	Sympathetic Block.	Sympathectomy.	Chordotomy.	Total.
<i>Major causalgia.</i>									
Transitory relief <sup>1</sup> .. ..	8	—	1	—	3	8	3	1	25
Improved .. ..	—	—	—	—	—	1	—	1	3
Persistent relief .. ..	—	—	2	—	1	2	1	4	10
<i>Minor causalgia and stump pain.</i>									
Transitory relief .. ..	—	2	—	—	1	1	3	—	7
Improved .. ..	1	—	—	1	—	—	—	1	3
Persistent relief .. ..	1	—	—	1	—	2	1	—	5
Total number of procedures .. ..	10	2	3	2	5	14	8	8	52

<sup>1</sup> "Transitory relief"—up to three months' relief only. "Improved"—pain persists with lessened severity. "Persistent relief"—pain absent.

plexus block after prior failure of a sympathetic block. In the other two cases in which sensory roots were cut intrathecally, anæsthesia occurred without persistent benefit. From our experience in these and other painful conditions rhizotomy seems unreliable. In the case in which benefit resulted probably some local intervention such as neurolysis or resection and suture, had it been feasible, would have been equally effective.

Preganglionic sympathectomy is generally considered to be the standard operative procedure for all types of causalgia. High proportions of satisfactory results have been reported (for example, Mayfield and Divine (1945), 100% success in 12 cases; Allbritten and Maltby (1946), 93% success in 30 cases; Spiegel and Milowsky (1946), 100% of 7 cases; Rasmussen and Freedman (1946), 73% of 40 cases). In our series, however, only two out of eight patients submitted to the operation were permanently benefited, although five others were relieved for from one to three months. This occurred in spite of such evidences of sympathetic interruption as persistent raised skin temperature and absence of sweating, as well as histological examination of the excised tissue. Three of these unsatisfactory sympathectomies were in the upper limb, two were lumbar sympathectomies for *cauda equina* injuries, and one was a lumbar sympathectomy for a high sciatic injury. It has been suggested (de Takats, 1945; Mayfield and Devine, 1945; Shumacher, 1947) that failure with sympathectomy in the leg after the customary



preganglionic excision (third and fourth lumbar segments) may be due to sympathetic fibres reaching the damaged segment of nerve from higher levels, and cases have in fact been reported in which a second and higher sympathectomy was then effective (Mayfield and Devine, 1945). This explanation, however, does not easily account for the failures of our three thoracic sympathectomies (preganglionic 1, postganglionic 2), all of which were for lesions in the hand, in which the lesion lay completely within the zone of sympathetic denervation. Nor does it account for failure with *cauda equina* lesions, as these are outside any but arterial sympathetic supply unless accessory sympathetic routes occur. There was no significant difference in the average duration of symptoms (approximately one year) between the cases in which response followed sympathectomy and those in which it did not. These results, however, harmonize with the evidence of Ray and Console (1948) that the ventral roots may acquire accessory sympathetic supplies. Section of the first lumbar ventral root often abolished sweating on the anterior part of the thigh after sympathectomy had failed to do so. A similar first thoracic area in the axilla was noted by Ray and Console. Reorganization of the sympathetic innervation within three months of operation through the motor roots would account for the results we report, with pain recurrence after the conventional procedures. In some the cord's function may have become fixed in its derangement so that it would respond neither to sympathectomy nor to chordotomy.

Antero-lateral chordotomy is usually regarded as a last resort, and has been little used in cases reported in the literature. Yet it was necessary in eight of our cases, seven of which were major causalgias. Chordotomy was employed only after other procedures had already been tried or were eliminated because of failure to the appropriate procaine block. In five cases relief was as complete as could be desired. These patients were not aware of any unpleasant numbness in the limbs, nor were there sphincteric disturbances. In the remaining three patients there were partial recurrences of pain and several complications. In one patient (Case VII), in spite of three separate sections of the antero-lateral columns, his pain persistently returned within two months of operation and objectively pain sensibility continued, indicating that there must be residual or alternate pathways for the pain impulses. Some shooting pain returned in Case XII after three months, but this patient remains ambulant and improved. In Case III after a bilateral chordotomy there were grave sphincteric disturbances lasting six months with periods of both retention and frequency of micturition. A deep abnormal pain returned in one leg, and in addition the root distributions in the cervical region corresponding to the sites of cord section became causalgic. This case (Case III) may be cited more fully.

At the age of twenty-seven years the patient, a nurse, was operated upon for prolapse of the fifth lumbar intervertebral disk causing unilateral sciatica. A central prolapse was removed, but bilateral leg pain and backache appeared, and so the disk was reexplored eleven days later and further pulp curetted away. The other disks seemed normal, as were the nerve roots. Subsequently her recovery was slow and pain persisted in both legs together with tenderness and weakness of the muscles. After three months it became apparent that she was suffering from causalgia, since there was a gradual onset of burning pain in the soles of her feet, and acute hyperpathia developed. Hypoalgesic bands apparently corresponding to the first sacral dermatomes extended up to her buttocks. The left ankle and knee joints swelled for some months.

At this stage lumbar sympathetic block with procaine gave four hours' relief from the pain, but a left-sided preganglionic sympathectomy was without more than a week's benefit. Bilateral chordotomy was then carried out in stages. A second thoracic segment chordotomy on the right side was followed by relief of pain on the opposite side, and a month later a seventh cervical segment chordotomy was performed on the left side. The right leg was then temporarily relieved, but a long period of sphincteric



disturbance followed, and shortly after the second section causalgia appeared in the distribution of the seventh and eighth cervical nerve roots on the right side. Meanwhile pain of a deep aching type returned in the right buttock, so a further seventh cervical segment chordotomy was undertaken on the left side, together with a seventh cervical segment posterior rhizotomy on the right. The causalgic pain persisted in the right hand, but a further causalgia appeared in the eighth cervical region of the left arm. In spite of these chordotomies a deep ache remains in the lowest sacral zones on the right side.

The cord sections precipitating causalgia in the hands could have produced causalgia either by their effects on the cord itself or on the neighbouring roots. As the signs of both arms and legs are confined largely to root distributions, it seems likely that the causalgic lesion was induced in the roots rather than centrally. There was, however, some overlap of signs on to neighbouring root areas, as is usual in causalgia. This case suggests that the spinal cord or nerve roots may need only very minor trauma to produce causalgia in a susceptible subject. In our series there were five cases in which operation near a nerve has led to causalgia of an intractable type. Prophylactic use of the tetraethylammonium ion might in future prevent some of these consequences (compare Collier *et alii*, 1947).

#### CONCLUSIONS.

In the practical aspects of diagnosis and treatment of these dysaesthesiae there are several points that require emphasis.

The absence of burning pain does not exclude a diagnosis of causalgia. Many cases do not approach the type or severity of those described by Weir Mitchell and repeated in textbook descriptions. In our series of both major and minor causalgias we find that aching, shooting and surging pains preponderate over burning pains, which may appear only transitorily in the course of the disease. Probably a transition of one type of pain to the other occurs frequently.

It is not difficult to overlook minor causalgias and to regard them instead as psychoneuroses. The patients complain of persistent pain, but unless rather careful tests for hypoalgesia, hyperpathia and weakness are made, the condition may go unrecognized and both proper treatment and a merited insurance benefit be denied. The signs of minor causalgia are similar to but less marked than those in major causalgia. Probably this is related to the degree of nerve damage. In major causalgia the injury affects an anatomically named nerve trunk; in minor causalgia it involves only the finer nerve ramifications caught up in soft tissue lesions.

In diagnosis and treatment the use of procaine solutions is invaluable. Before any operation is undertaken it is prudent to infiltrate the nerve pathways at appropriate levels with a local anæsthetic agent and to wait a day or so to observe the result. Further interference may be made unnecessary or useless surgery may be prevented. Tetraethylammonium bromide offers prophylactic and therapeutic aid of a kind similar to sympathetic blocks and may be used as an early prophylactic measure.

In our experience the psychoneurotic element in causalgia is usually small and preliminary diagnoses have erred in the direction of a suspicion of malingering rather than of emphasis of organic disorder.

We have reemphasized the frequent failure of amputation, rhizotomy and neurotomy to alleviate the causalgias, although occasionally they may be successful. The six unsatisfactory sympathectomies in our series are not easy to account for. It may be that an insufficient extent of sympathetic supply has been removed, as suggested by Shumacher (1947). But it seems more likely that in these cases sympathetic nerves travelled with the motor roots (Ray and Console, 1948) or that the peripheral nerve lesions could maintain pain cycles without the sympathetic nerves. When other measures

failed we have found spinothalamic tract section to be a useful operation with one main risk: that was the production of root causalgia at a higher level—at the level of the cord section. A similar condition occurred in one Smithwick thoracic sympathectomy, in which pain developed in the territory of a divided thoracic nerve. The general problem of the relation of causalgias to operation arises in this context. Five patients developed causalgia in one to three days after some elective surgical procedure had been performed (two in our hands and three by others). This complication of operation contributed 24% of our series of cases. Causalgia is thus a definite hazard of surgery involving nerves, and for its prevention two methods suggest themselves. The first is the avoidance of trauma to nerves during exposure; and the second, should any causalgic pain appear, is the prompt use of sympathetic blockage by procaine or tetraethylammonium bromide.

The fact that there is a residuum of cases of causalgia in which relief has not been obtained, makes it necessary to consider further procedures. The possibilities are prefrontal leucotomy and cortical excision. Leucotomy is more likely to alter the awareness of pain than actually to abolish it. On the other hand excision of the appropriate area of the parietal cortex appears to offer the possibility of relieving the pain without risks to the personality. The relief has not been permanent (Sweet, 1947, de Gutiérrez-Mahoney, 1948) in four out of five cases in which operation was performed. The extensive cortical (dual and bilateral areas) and possibly thalamic representation of somatic sensation in the brain makes it likely that bilateral cortical excision of parts of area 3 would be necessary for effective treatment.

#### SUMMARY.

1. The aetiology of post-traumatic pain states (causalgic syndromes) is reviewed. Evidence favours: (a) The production, by a peripheral focus of injury in a nerve, of sustained discharges from cord neuron pools. These would result in widespread pain, with sensory, motor, sympathetic and trophic disturbances. (b) Fibre interaction between sympathetic or other efferents and the somatic afferent fibres, at the site of injury, feeding the irritable internuncial neuron pool.

2. Twenty-one cases of various types of syndrome are described and classified. Aching, as well as burning pains, occurs in both major and minor causalgias and in painful amputation stumps. Transitions from one pain type to another are recorded.

3. No single surgical approach will afford relief in all cases of causalgia. In this series five patients were permanently relieved by local infiltration of procaine into tender areas or the sympathetic chain. The others required neurotomy, sympathectomy or chordotomy. Only two of eight patients in whose treatment sympathectomy was employed had permanent relief.

4. Causalgia as a complication of elective surgical procedures involving nerves or spinal cord was encountered in five cases.

#### ACKNOWLEDGEMENT.

I wish to thank Mr. M. A. Falconer, M.Ch., F.R.C.S., for the opportunity to study these cases occurring in his neurosurgical service, for his stimulation and for his helpful comments.

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## INSTRUMENTS FOR INTRAABDOMINAL RESECTION AND ANASTOMOSIS FOR CARCINOMA OF THE RECTUM.<sup>1</sup>

By EDWARD WILSON,  
*Sydney.*

If the patient is thin and small the technical difficulties of making an anastomosis in the depths of the pelvis after an intraabdominal resection of the rectum are easily overcome; but in the obese patient these difficulties may appear insurmountable, and indeed they may well be unless, *inter alia*, suitable instruments are available. In this paper some such instruments are described. It is not intended to suggest that they differ greatly from

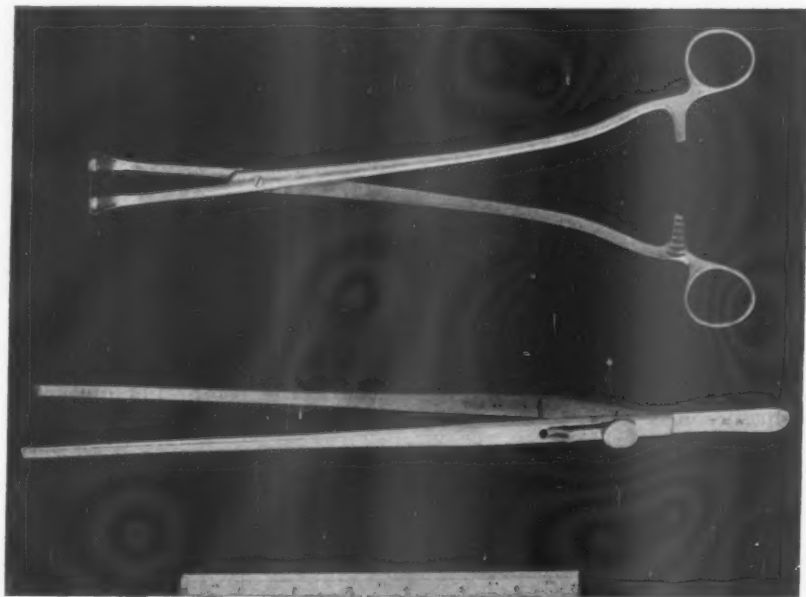


FIGURE I. (The scale shown is in inches.)

those usually employed in general surgery; rather it is hoped to emphasize the point that in the obese patient this operation can be facilitated by having at hand some additional, albeit simple, instruments.

There are already many types of angled clamps, but most of the long ones are too large and heavy to be of value to the proctologist. The clamps shown in Figures I and II are long and robust without being awkward to use. The jaws have rounded ends to lessen the chance of their penetrating

<sup>1</sup> Accepted for publication on May 17, 1948.

<sup>2</sup> The justification for the use of intraabdominal resection and anastomosis for carcinoma of the rectum is discussed elsewhere (Wilson<sup>(2)</sup>).

the rectum whilst they are being applied, their sides are wide and flat, and the faces of the jaws are grooved longitudinally.

After one of these clamps has been applied to the bowel the second is placed on the opposite side of the bowel below the first and then moved up till the two are in contact. The blades are sufficiently wide to prevent their

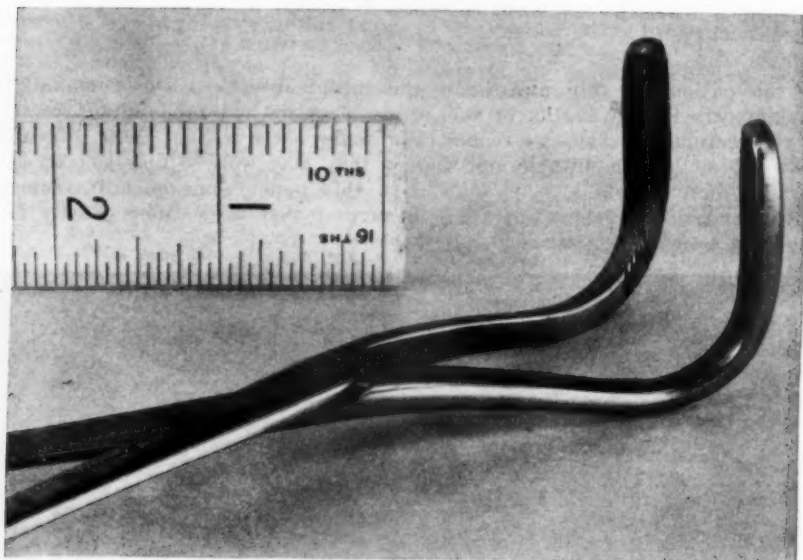


FIGURE II. (The scale shown is in inches.)

overriding, and it is easy to tell when they are in contact. They are easily applied and therefore the handling of the bowel before and during their application may be reduced to a minimum.

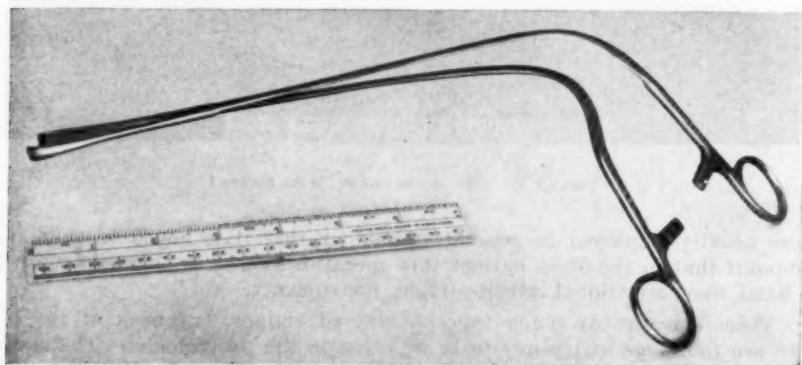


FIGURE III. (The scale shown is in inches.)

In order to prevent implantation of fragments of the tumour in the suture line the clamps should be applied above and below the tumour early



in the course of the operation. Whenever possible, this should be carried out immediately after the peritoneum on the sides and front of the rectum has been divided and before the remainder of the rectum has been mobilized. After the clamps are in place the distal portion of the rectum should be irrigated with a solution of 1 in 2,000 perchloride of mercury.

The tissue forceps illustrated in Figure III have the handles doubly curved like Magill's intratracheal catheter forceps; but they have been made with the curves to the right and to the left. These forceps may be used for holding the sides of the distal portion of the rectum, and because of the double curve they lie comfortably on each side of the wound and do not obstruct the line of vision. Their straight portions are nine inches long and the jaws are grooved longitudinally like Babcock's tissue forceps.

In Figure I is shown a pair of dissecting forceps which are thirteen and a half inches long, have four to five fine teeth, and have an old type of adjustable clip, so that, when desired, they may be firmly applied to the tissues without continued pressure of the fingers and thumb. This has been found advantageous during dissections at a depth.

The other special instruments that are useful during this operation in the obese patient are a long needle holder, a wide and deep retractor, scissors at least twelve inches long, an angled knife,<sup>(1)</sup> a deep ligature carrier,<sup>(2)</sup> and modified Moynihan gall-bladder forceps eleven and a half inches long (obtainable from John Bell and Croydon, Limited, London, W.1, and useful for obtaining hæmostasis in the depths of the pelvis).

#### SUMMARY.

Some instruments are described for intraabdominal resection and anastomosis of the rectum in the obese patient.

#### ACKNOWLEDGEMENT.

My thanks are due to Messrs. A. L. Hawkins, Limited, of New Cavendish Street, London, W.1, for the preparation of the instruments illustrated above.

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<sup>(3)</sup> O. H. Wangenstein: "Primary Resection (Closed Anastomosis) of Rectal Ampulla for Malignancy with Preservation of Sphincteric Function", *Surgery, Gynecology and Obstetrics*, Volume lxxxi, 1945, page 1.

## PULMONARY TORULOSIS.<sup>1</sup>

By KENNETH W. STARR and BRUCE GEDDES,

*From the Repatriation General Hospital, Concord, New South Wales.*

N.J.B., an ex-soldier, aged twenty-one years, was admitted to the Repatriation General Hospital, Concord, New South Wales, in March, 1947, as a reject on account of a radiographic opacity at the base of the left lung, detected in his microfilm.

At this stage he was completely symptomless. He reacted to the Mantoux test. Bronchoscopy was performed and, apart from a small amount of thick secretion which

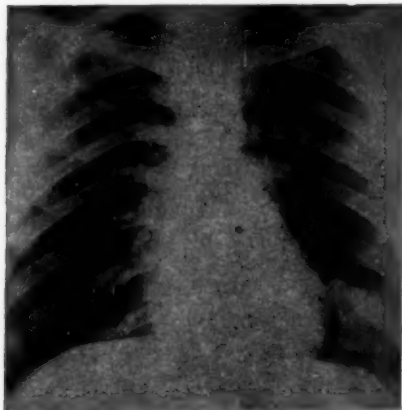


FIGURE 1A. Antero-posterior radiograph of the chest showing the shadow in the lower lobe of the left lung. Taken in March, 1947.

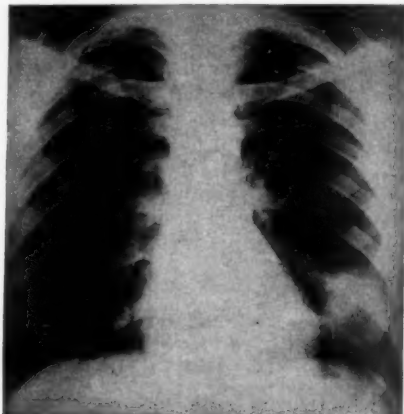


FIGURE 1B. Antero-posterior radiograph of the chest to show the increase in size of the shadow in the lower lobe of the left lung. Taken in August, 1947.

was aspirated from the left lower bronchus, no abnormality was detected. No cultures of acid-fast bacilli were obtained.

Progress X-ray and bronchographic examination in May, 1947, revealed no further abnormality and a diagnosis of pneumonitis was made. This latter diagnosis was again made on July 15, 1947, when the patient developed cough and sharp pain in the left side of his chest.

He was readmitted to hospital with very slight and occasional pain, a mild cough, producing about one drachm of sputum per day, but with loss of seven pounds in weight in the previous three months, despite a good appetite. There were no abnormal features in his previous or family history or personal habits. The opacity in the left side of his chest had increased slightly in size. His sedimentation rate was two millimetres in the first hour; the leucocyte count was 9,200 per cubic millimetre, with a normal differential count. The Casoni test gave a doubtful positive reaction, but the hydatid complement fixation test gave a negative result.

On August 26, 1947, a diagnostic pneumothorax was induced. It was apparent that the lesion was in the lung parenchyma. Bronchoscopy and bronchography were repeated, but the lipiodol did not enter the opacity when introduced for bronchography. Attempts to produce cultures from sputum and stomach washings were unsuccessful. Thoracotomy was therefore decided upon.

On October 23, 1947, thoracotomy and left lower lobectomy were performed.

Anæsthesia was induced with cyclopropane and oxygen, "Omnopon", one-third grain, and scopolamine,  $\frac{1}{100}$  grain, having been administered one hour before operation.

<sup>1</sup> Accepted for publication on June 28, 1948.

The throat was sprayed with 2% "Decicain", 0.25 gramme of "Pentothal Sodium" was given intravenously, and anaesthesia was maintained with an endotracheal McGill tube,

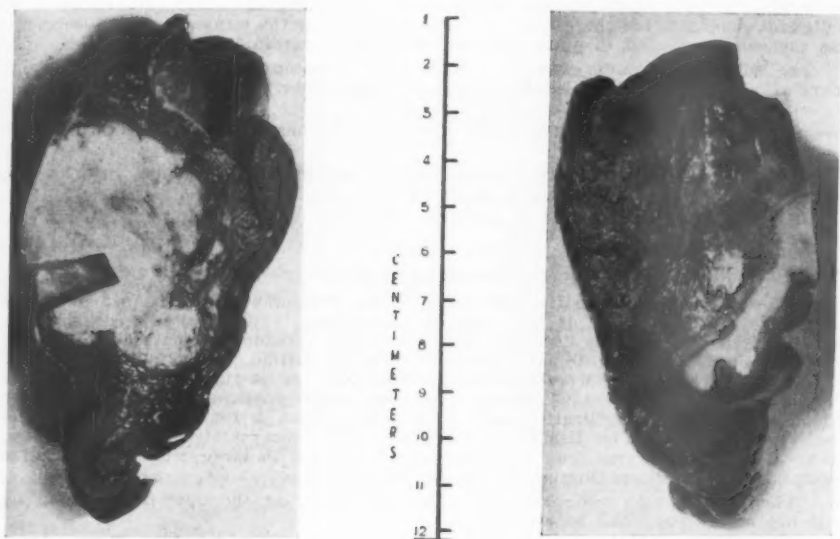


FIGURE IIA.

FIGURE IIB.

FIGURES IIA and IIB. Macroscopic appearance of the tumour from the medial and anterior aspects, respectively.

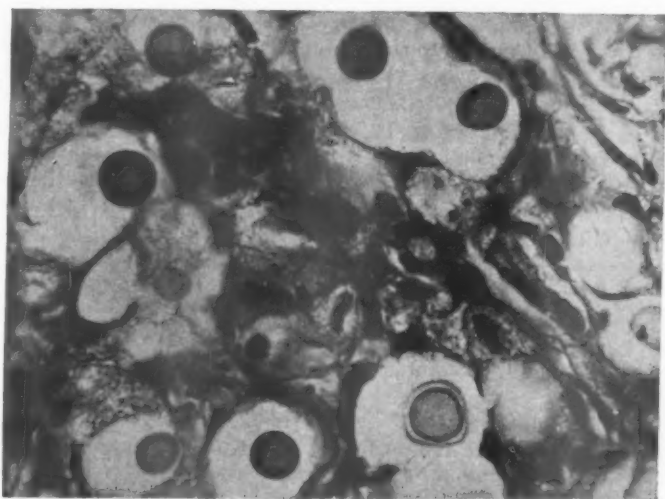


FIGURE IIC. Microscopic appearance of the tumour ( $\times 450$ ) to show the torular bodies.

size 10, with an inflatable cuff. Respiration was controlled throughout, apnea being maintained during separation of pericardial adhesions. The systolic blood pressure

was 170 millimetres of mercury throughout the operation, and the pulse rate 70 to 80 (Dr. J. McCulloch).

A mass the size of the human fist was discovered at the lower edge of the left lower lobe. It was white, hard and obviously infiltrating the lung. It resembled a malignant condition, but there were no enlarged glands at the hilum. A high lobectomy was therefore preferred to pneumonectomy and was accordingly performed.

The subsequent course was uneventful. Bronchoscopy was required forty-eight hours after operation for atelectasis of the left upper lobe.

The patient's convalescence was prolonged by transfer to a neurological ward for investigation, in view of the pathological report, but the nervous system was pronounced clear of torular infection.

Sputum examination since operation and attempts to produce cultures on Sabouraud's medium have revealed no fungus.

The patient is now well and working, and when last seen in June, 1948, was symptomless.

#### Pathological Report.

"The tumour present in the lower lobe of the lung was an oval-shaped mass, 4.5 centimetres in diameter. It was firm in consistency, yellow-white in colour, and showed areas of gelatinous degeneration. The lesion extended to the pleural surface, where it appeared as a white shiny patch of irregular outline. It was quite hard when felt at operation. There were two further small patches of tissue in the lower lobe outside the limits of the main tumour. The microscopic appearances were as follows: There was a cellular infiltration with large foam cells. A few multinucleated cells were also present. The tissue contained numerous encapsulated yeast-like bodies. Many of these were lying free, but some were contained in large cells. Degenerative changes were prominent throughout the tumour.

"The small lymph node removed from the hilum at the operation showed no evidence of the yeast-like bodies."

#### Comment.

Proven cases of torulosis of the lungs are rare.<sup>(1)</sup> Suspected cases, without extrapulmonary involvement, are difficult to demonstrate, are often symptomless, and may heal spontaneously.

It is therefore difficult to predict the prognosis in this case.

#### Reference.

- <sup>(1)</sup> L. Cox and I. Tolhurst: "Human Torulosis", 1946.

## THE USE OF PLASTIC TUBING IN INTRAVENOUS THERAPY.<sup>1</sup>

By J. SUNDERMAN and D. G. RENTON.

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A RECENT review of the work of the Neurosurgical Unit of the Alfred Hospital revealed that venoclysis was required in approximately 30% of cases. There were two distinct groups: (a) those in which blood, saline solution, a dehydrating agent or a chemotherapeutic drug had to be given at a slow rate over some considerable time; (b) those in which a sudden blood loss necessitated a large volume replacement in a short time.

It was also found that neither the glass cannula of the standard intravenous set nor a metal needle in the vein was altogether ideal. Both are rigid and have sharp points and edges which cause undue trauma to the vein, disposing to clot formation, pain and severe restriction of movement of the patient. Uncontrolled movement of an uncooperative patient frequently dislodged the cannula or needle.

The ideal cannula would be an easily sterilizable, flexible, blunt-tipped, non-irritating tubing, biologically and chemically inert, and having a low coefficient of friction.

Plastic tubing of the polythene ("Nylex E") type possesses these properties and there have been favourable reports on its use from the Mayo Clinic.<sup>(1)(2)</sup>

Through the courtesy of Dr. Lundy, of the Clinic, a sample of American polythene tubing was made available for trial. The potentialities of the material prompted local production of a suitable tubing, "Nylex E", in various sizes.

### PROPERTIES OF POLYTHENE (POLYETHYLENE, "NYLEX E").

Polythene is a plastic, pearly grey or colourless and semi-transparent in appearance. It is flexible, tough, elastic, light (specific gravity 0.92) and easily moulded at its softening point (110° C.). It is an excellent electrical and thermal insulator and has a low coefficient of friction.

It is chemically inert, being insoluble in water, acids, alkalis, gases such as fluorine and all known organic solvents at 60° C. or less. Biochemically it is also completely inert, with no evidence of foreign body or inflammatory reaction when buried in the body cavities or tissues.

It is cheap, easy to produce and is easily sterilized by boiling water or chemicals.

### TECHNIQUE OF INTRAVENOUS INTUBATION.

The chosen vein is punctured in the direction of its flow by a suitable needle. The plastic tubing is introduced through the needle and passed several inches up the vein. The needle is then removed, the tubing being left in the vein. The delivery tube of a standard intravenous set is connected to the end of the plastic tubing by means of a blunt intravenous needle of suitable size.

<sup>1</sup> Accepted for publication on June 28, 1948.

A "Julian Smith" blood transfusion needle of external diameter 1.6 millimetres (0.0629 inch) and a bore of 1.3 millimetres (0.0512 inch) is the needle of choice.

The size of plastic tubing used for this puncture technique is limited by the bore of the needle used for its introduction. The American polythene tubing has an external diameter of 0.033 inch and a bore of 0.025 inch. This size allows administration of aqueous solutions at a rate of about 60 drops per minute with a gravity head of pressure of four feet, and of citrated blood at about 40 drops per minute through a 15-inch length of polythene tubing.

The most satisfactory sample of locally made tubing yet to hand has an external diameter of 0.047 inch and a bore of 0.028 inch. An attempt is being made to increase the bore of this tubing.

When a more rapid administration is desired, a larger plastic tube is used instead of a glass cannula or a metal intravenous needle. Standard commercial "Nylex" tubing of bore 1.0 millimetre (0.0394 inch) and external diameter of 1.9 millimetres (0.074 inch) has been satisfactory. It may be introduced through a larger needle. More commonly the vein is exposed in the usual manner, its wall incised and a bevel-ended piece of tubing inserted several inches into the vein. A pad strapped lightly over the wound prevents leakage at the point of entry. The plastic tubing is joined to the delivery tube of the infusion apparatus by a suitable needle or other connexion.

This set-up allows considerable movement of the limb without fear of dislodging the tubing. It is more comfortable for the patient. There have been no thrombosed veins from its use.

Locally manufactured "Nylex E" tubing is not yet on the market, but doubtless soon will be. Commercial "Nylex" insulating tubing is readily available. It is manufactured in a range of sizes—commercial sizes indicate bore of the tubing, not the external diameter—from 1.0 millimetre to 4.0 millimetres in steps of 0.5 millimetre and from 4.0 millimetres to 40.0 millimetres in steps of 1.0 millimetre.

"Nylex" tubing is cheap and may with advantage replace rubber tubing for many purposes.

#### ACKNOWLEDGEMENTS.<sup>1</sup>

We acknowledge with thanks the cooperative interest of Mr. Neil Taylor, of Moulded Products, Limited, and the company who made and supplied the tubing, and of Mr. Kelly, of the A.P.I. Cables and Insulation, Proprietary, Limited.

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<sup>1</sup> American polythene capillary tubing is now available in Australia.



## SEGMENTAL PULMONARY RESECTION.<sup>1</sup>

By DOUGLAS ROBB,  
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My purpose is to record experience confirming the practicability in many cases of limiting the amount of pulmonary tissue resected to units smaller than the five major lobes. This is obviously an advantage, particularly in such conditions as bilateral bronchiectasis, in which the patient needs any good lung tissue he has on his tree. It so happens also that the methods devised for this purpose may be used to facilitate lobectomy itself where the limits of the lobe are obscured or absent on account of failure of the normal fissures to develop, or their later obliteration by adhesions (Robb, 1948).

The recognition of anatomical and functional broncho-pulmonary segments within the five larger lobes has proceeded steadily since bronchoscopy and thoracic surgery have been practised freely. Notable students of the subject include Nelson, Kramer and Glass, Hardie Neil, Gilmour and Gwynne, Foster-Carter, and Brock. The detailed anatomical work relating to the divisions of the pulmonary artery and vein, and to the external appearances of the bronchi in their respective hila came later, notably by Blades, by Clagett and Deterling, and by Overholt and Langer.

The lingula of the left upper lobe was the first segment at issue from the surgeon's point of view. It was frequently affected in one or both of its main divisions in bronchiectasis either alone or very commonly in conjunction with all or most of the segments in the left lower lobe. To remove the lower lobe and leave the lingula was at best only a modified success. Early methods of lingulectomy, by the use of a series of clamps along what were judged (or guessed) to be the limits of affected tissue, followed by transfixion and suture, were better than nothing, but were inelegant and inaccurate. Dissection in the lower part of the fissure readily reveals the lingular bronchus and its two main divisions, and also the branch of pulmonary artery and tributary of the pulmonary vein going to and coming from the lingular segment. With these secured and divided, a remarkable avascular plane of cleavage between the lingula and the adjacent part of the upper lobe is found and opened up by finger or gauze dissection. The lines of demarcation on the visceral pleura soon become obvious, and may be further emphasized by increasing the pressure within the tree, the lingular segment of course remaining collapsed. Incision along these lines frees the lingula completely. The stump of bronchus is sutured or perhaps ligated, and the raw surface of the upper lobe may be covered by a few cotton sutures joining opposite points on the pleura. In one of our cases only the lower of the two main branches of the lingular bronchus was bronchiectatic; its removal and the leaving of the normal branch presented no difficulty.

The apical or first dorsal segment of the lower lobe was the next to attract attention, for it is a large segment, and one frequently to escape bronchiectasis even when all the basal segments of the lower lobe are affected and the lingula as well. Interest in its conservation was aroused, and it was found easy to display its bronchus, artery, and vein by continuing the dissection of the hilum of the lower lobe from the front (as for the lingula) together with an approach from behind to display the veins. Again the avascular

<sup>1</sup> Read at the annual meeting of the Royal Australasian College of Surgeons, Dunedin, January, 1948. Accepted for publication on May 17, 1948.

plane between the apical segment and the remainder of the lower lobe is found easily, and inflation of the apical demarcates the lines on the pleural

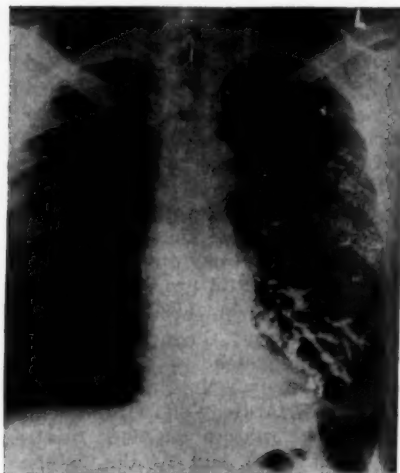


FIGURE I. Case II. Postero-anterior bronchogram on left side, showing gross bronchiectasis of lingula. The lower lobe had been removed previously.



FIGURE II. Case II. Lateral bronchogram on left side, showing gross bronchiectasis of lingula. The lower lobe had been removed previously. (In the printing of the films the right and left sides have been reversed.)

surface for incision. The raw surface remaining can be covered over as before. The middle lobe of the right lung lends itself admirably to this method,

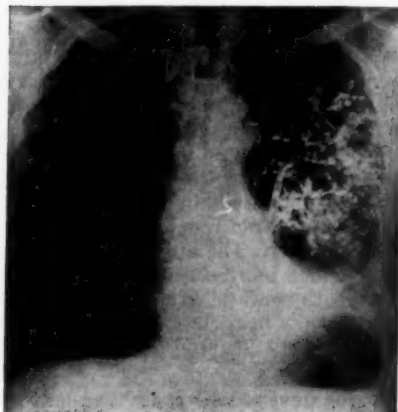


FIGURE III. Case II. Postero-anterior bronchogram on left side, post-operative, showing clearance of all bronchiectasis and good filling of remaining segments of upper lobe.



FIGURE IV. Case II. Lateral bronchogram on left side, post-operative, showing clearance of all bronchiectasis and good filling of remaining segments of upper lobe. (In the printing of the films the right and left sides have been reversed.)

especially when the fissures are shallow or partially missing. This was the case in our Case VI, in which the lesser fissure was shallow and short behind

and non-existent in front. The hilum of the middle lobe was therefore dissected from below (greater fissure) and the lobe was separated from the upper lobe by the same type of blunt dissection after bronchus, artery and vein had been secured and divided.



FIGURE V. Case III. Postero-anterior bronchogram, left side, showing gross confluent bronchiectatic spaces with apical segment of lower lobe unaffected.

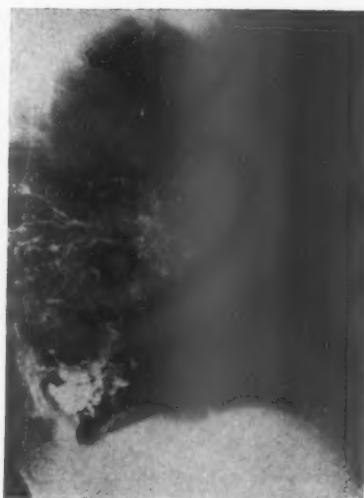


FIGURE VI. Case III. Lateral bronchogram, left side, showing gross confluent bronchiectatic spaces with apical segment of lower lobe unaffected. (In the printing of the films the right and left sides have been reversed.)

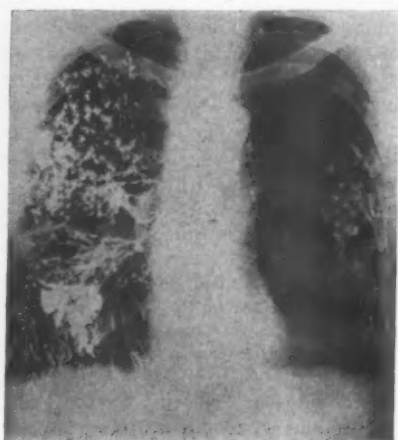


FIGURE VII. Case III. Bronchogram, right, showing middle lobe affected.



FIGURE VIII. Case III. Postero-anterior bronchogram, left side, post-operative, showing clearance of bronchiectasis and a sizable portion at least of lower lobe apical segment filling well.

The method has not yet been applied by us to other segments, but in two other cases its application to lobectomy in the absence of the usual help of

fissures has been gratifying. In Case IV bronchiectasis affecting the three basal segments of the left lower lobe was present, leaving the lingula and first dorsal segment of the lower lobe free. Dense, troublesome adhesions lay between the lower lobe and chest wall, diaphragm and pericardium. The fissure was visible in its posterior third only and was shallow. Dissection was begun below the hilum, identifying the veins first, saving the tributary from the dorsal segment. The bronchi were then identified, and the dorsal one was saved and its patency was shown by inflation, the main stem beyond it being divided. Traction on the distal stump brought the artery and its branches into view, and the division was carried out below the branch to the dorsal segment. Two avascular planes were now to be sought—that between the dorsal segment and the remainder of the lower lobe and that between

the lower lobe and the upper, where the normal fissure could not be seen. The former was dissected first and then the latter, the separation seeming crude in the process, but when finished leaving two raw planes intersecting at the hilum. These surfaces were not covered. Convalescence was uneventful, penicillin being used. Four months later a bronchogram showed good filling of the dorsal segment so saved, and also of the lingula, which swept down and backwards to fill the space. Its two bronchi were also quite intact.

In Case V bronchiectasis affected the whole lower lobe and the lower of the two main divisions of the lingular bronchus. The main fissure was evident in only the upper and posterior third of its length and was shallow. The remainder seemed developmentally absent. A chain of enlarged glands lay behind the hilum of the lower lobe. Dissection was begun below the hilum of the lower lobe and the veins were secured.



FIGURE IX. Case III. Lateral bronchogram, left side, post-operative, showing clearance of bronchiectasis and a sizable portion at least of lower lobe apical segment filling well. (In the printing of the films the right and left sides have been reversed.)

Bronchi and arteries were next displayed, in each case those to the dorsal segment being differentiated and divided separately. The lines for incision of the visceral pleura over the anterior part of the invisible fissure were now obvious and an easy blunt dissection removed the lower lobe. Through a thin layer of lung tissue in the raw surface of the lingula the lower bronchiectatic tube was seen. It was traced up to the main lingular stem bronchus and divided there, and was removed with a strip of surrounding lung, the lingular stem and upper main bronchial division being left intact. Some trouble in retaining inflation of the upper lobe was encountered in the succeeding days, necessitating bronchoscopy and aspiration of the pleural space, but convalescence was not delayed and clinical cure resulted. A post-operative bronchogram has not yet been made.

It is hardly necessary to labour the necessity for good preliminary bronchograms in at least two projections and their careful interpretation, in this work, so that an exact plan of action is mapped out before operation.

One important aspect remains to be mentioned: that is the degree of function attained by the healthy segments saved in this manner. All these patients have been operated on in the last six months, and we have so far



FIGURE X. Case IV. Postero-anterior bronchogram on left side, showing bronchiectasis affecting three basal segments of lower lobe, leaving apical segment (also lingula of upper lobe) intact.



FIGURE XI. Case IV. Lateral bronchogram on left side, showing bronchiectasis affecting three basal segments of lower lobe, leaving apical segment (also lingula of upper lobe) intact. (In the printing of the films the right and left sides have been reversed.)



FIGURE XII. Case IV.—Postero-anterior bronchogram on left side, post-operative, showing clearance of bronchiectasis and well-filling apical segment of lower lobe. The lingular bronchi show very well.



FIGURE XIII. Case IV. Lateral bronchogram on left side, post-operative, showing clearance of bronchiectasis and well-filling apical segment of lower lobe. The lingular bronchi are seen to pass down and strongly backwards. (In the printing of the films the right and left sides have been reversed.)

secured only three post-operative bronchograms (Cases II, III and IV). These, however, show an excellent immediate result with some unavoidable

distortion, but with no bronchiectasis and apparently good aeration around. Late results—two, five and ten years further on—will also need study. In all cases save one—Case I—the post-operative course with penicillin has been very favourable and would lead one to expect a good functional result.

#### BRIEF DETAILS OF SIX CASES.

CASE I.—Mrs. Z.O., aged thirty-four years, had gross bilateral bronchiectasis. Her general condition was much improved by physical treatment on a rocking stretcher. The left side was tackled first by left lower lobectomy and lingulectomy. Formal dissection from the lower part of the interlobar fissure and later posteriorly to the hilum of the lower lobe displayed all structures as expected—bronchi and vessels to the first dorsal segment, to the remainder of the lower lobe, and to the lingula. The last-mentioned bronchus was seen dividing into two. The usual blunt dissection was carried out in removal of the lingula. Convalescence was stormy. Fourteen days after lobectomy thoracotomy with evacuation of fibrin clots and decortication of the upper lobe was required. Finally, full expansion of the upper lobe was obtained. The right side remains to be dealt with.

CASE II.—S.W., aged forty-one years, suffered from bronchiectasis, for which left lower lobectomy had been performed elsewhere two years before. Almost at once afterwards cough and sputum reappeared and a bronchogram showed the lingula to be grossly affected. Dissection at the lower aspect of the hilum displayed the stump of the lower lobe bronchus, then a half-inch wide bronchus dividing into two quarter-inch bronchi. Clamping of the half-inch bronchus allowed the whole upper lobe to inflate except the lingula. Removal of the lingula was carried out by division of the bronchus and vessels and the finding of the avascular plane. Convalescence was uneventful. Four months later a post-operative bronchogram showed a complete clearance of the bronchiectasis and normal remaining tubes.

CASE III.—Mr. T.M., aged forty-seven years, suffered from bronchiectasis affecting the right middle lobe and the lower three segments of the left lower lobe, and leaving the first dorsal segment and lingula intact. Partial left lower lobectomy was performed, the first dorsal segment being spared by formal dissection first at the front and then behind the hilum of the lower lobe. Convalescence was uneventful; attention will be needed to the right side later. A post-operative bronchogram showed a substantial part at least of the left apical segment in good heart and no bronchiectasis remaining on the left side.

CASE IV.—Mr. C.K., aged twenty-two years, suffered from bronchiectasis of the three basal segments of the left lower lobe. The first dorsal segment was conserved. The lingula was healthy. Convalescence was uneventful.

CASE V.—Miss L.McW., aged nineteen years, suffered from bronchiectasis affecting the whole of the left lower lobe and the lower only of the two main divisions of the lingula. The interlobar fissure was poorly developed, being visible in the upper part only. Dissection of the hilum of the lower lobe from below displayed very clearly the limits of the upper and lower lobes anteriorly. Through the raw surface of the lingula after the lower lobe had been removed the diseased branch of the lingular bronchus was identified and removed with its lung tissue, the upper branch being left intact. Convalescence was satisfactory.

CASE VI.—Mr. D.S., aged twenty years, had a huge teratoma of the anterior mediastinum, adhering to and thought to be invading the right middle lobe, necessitating lobectomy in addition to the removal of the tumour. The lesser fissure was very poorly developed, but a dissection from below the hilum of the middle lobe made the operation easy. Convalescence was very satisfactory.

#### SUMMARY.

On a basis of six cases segmental pulmonary resection is found to be eminently practicable at least as far as the middle lobe, lingula, apical or first dorsal and lower basal segments go. Convalescence on the whole has been good to excellent. In three of the cases post-operative bronchograms show healthy bronchi in the portions conserved, but no late results are available.

The principle of securing bronchus and vessels and then peeling the segment off through an avascular plane has also been applied with success in lobectomy in cases with poor or absent fissures.



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## RESTORATIVE RESECTIONS FOR CARCINOMA OF THE RECTUM.<sup>1</sup>

By EDWARD WILSON,<sup>2</sup>  
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INTRABDOMINAL (anterior) resection and sutured anastomosis is the method of choice for restorative resection of the rectum and is clearly described in the papers of Dixon<sup>(1)</sup> and Wangenstein.<sup>(2)</sup> The other restorative procedure commonly employed in some clinics is the Babcock-Bacon abdomino-perineal proctosigmoidectomy;<sup>(3)(4)</sup> but by no means all patients have complete control of their bowels after this operation. An imperfectly controlled perineal anus may look better than an abdominal colostomy when both are clean, but not when soiled with faeces; and it may well be argued that any extra risk entailed by a restorative procedure is not justified if incurred in saving sphincters over which future control may be imperfect.

This discussion will be confined to a consideration of the justification for the use of intraabdominal resection and anastomosis of the rectum, a procedure which does not interfere with the function of the anal sphincters.

Excision of the rectum should be performed only by those who are well versed in the treatment of carcinoma of the rectum and not by the "occasional" surgeon. This especially applies if the method of excision chosen is that of intraabdominal resection and anastomosis, for this procedure possesses additional problems of its own. As an example of the results that may be obtained by those surgeons specializing in the treatment of carcinoma of the rectum some figures from Saint Mark's Hospital may be quoted.<sup>(5)</sup> In 1947 the operability (resectability) rate for carcinoma of the rectum was 86% and the mortality rate of operations for carcinoma of the rectum was 8%. These figures are all the more notable when it is realized that they include all cases of carcinoma of the rectum referred to the out-patient department, whether the patients were admitted to the hospital or not, whether they were obviously moribund when first seen, or whether they refused operation. The mortality rate included all deaths in hospital from any cause. In addition to being well versed in the treatment of carcinoma of the rectum, the surgeon who treats this disease should have available the assistance of an expert pathologist.

At Saint Mark's Hospital during the years 1938-1942 an abdomino-perineal,<sup>(6)</sup> perineo-abdominal<sup>(7)</sup> or synchronous combined<sup>(8)</sup> excision was performed on 301 patients suffering from carcinoma of the rectum. Of these patients, 121 were known to be alive and well after five years; four were untraced (see Table I). In 42 of the surviving 121 patients the superior hæmorrhoidal lymph glands were found to contain metastases, that is, they were classed as "C" cases.<sup>(9)(10)(11)</sup>

Of the series of 301 patients, the two larger groups—(a) the 176 "A", "B" and "C" patients who died in hospital or who from any cause did not survive for five years, and (b) the 79 "A" and "B" patients who did survive for five years—have gained nothing extra in having a combined radical

<sup>1</sup> Accepted for publication on May 17, 1948.

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<sup>3</sup> Further details of this group of cases will be found in a recent address to the Mayo Clinic by Morgan.<sup>(12)</sup>

<sup>4</sup> The average number of lymph glands containing metastases in the specimens removed from these 42 surviving "C" patients was three, a figure which was to be expected (Dukes<sup>(13)</sup>).

operation<sup>1</sup> with a permanent colostomy instead of a restorative resection.<sup>2</sup> This latter procedure would not, of course, have been possible in all cases;<sup>3</sup> but if in these two groups of patients a restorative resection had been performed whenever possible, then, as it turns out, there would not have been any less survivors amongst them.

This leads to the conclusion that, apart from the four who were untraced, the only patients who may have gained any extra benefit from the combined radical operations were the 42 "C" patients who were known to be alive and well five years after their operations.

TABLE I.

*Details of 301 Patients in whom an Abdomino-perineal, Perineo-abdominal or Synchronous Combined Excision was Performed for Carcinoma of the Rectum at Saint Mark's Hospital in the Years 1938-1942.*

Dukes's Classification. (91) (10)	Deaths in Hospital or did Not Survive for Five Years. <sup>1</sup>	Untraced.	Alive and Well Five Years After Operation.
A .. ..	16	1	29
B .. ..	45	2	50
C.1. .. ..	76	Nil	38
C.2. .. ..	39	1	4
Total ..	176	4	121

<sup>1</sup> These figures include all deaths, whether due to carcinoma of the rectum or not.

An estimate of the number of these "C" patients who survived for five years and from whom perhaps only the combined radical operation would have removed all the affected lymph glands, may be obtained from a study of the pathological reports. In only 12 of the 42 did the proven lymphatic spread extend for more than two inches from the upper edge of the primary tumour. So that if, for the moment, we assume that only the lymph glands which do not extend beyond two inches from the primary tumour are certain to be removed by a restorative resection (supposing that such was otherwise possible), then out of every 297<sup>1</sup> patients on whom a combined radical operation is performed, and of whom 121 survive for five years, there will not be more than 12 who would be cured by this procedure but who might not be cured by a restorative resection. To obtain this benefit for the 12 some of the remaining 285 will have to suffer an unnecessary colostomy permanently.

It is not possible to state accurately in what percentage of cases a restorative resection would be possible, for this remains quite a controversial point; but when all the factors, such as the length and arrangement of the sigmoid and inferior mesenteric vessels, the position and size of the tumour, the length of the rectum and of the sigmoid colon, the general condition of the patient, the experience of the surgeon, and the possible presence of a second neoplasm, are considered, the figure is likely to be in the region of 50%. This point is being discussed by Goligher<sup>(17)</sup> in a paper now awaiting publication.

<sup>1</sup> The term "combined radical operation" is used in this paper to include the abdomino-perineal, perineo-abdominal and synchronous combined excisions of the rectum.

<sup>2</sup> It is assumed here that a restorative resection has the same operative mortality and morbidity rates as the combined radical procedures. This point will be referred to again later.

<sup>3</sup> During the years 1938-1942 no patient with a carcinoma of the rectum was treated at Saint Mark's Hospital by an intraabdominal resection and anastomosis or by a Babcock-Bacon operation.

<sup>4</sup> The original figure of 301 less the four who were untraced.

If we accept here this figure of 50% as the percentage of the patients in whom a restorative operation would be possible and if we reduce the number of survivors to the round figure of 120, we seem to have the choice, on the one hand, of 120 patients alive and well with colostomies or, on the other hand, of a group of 60 patients alive and well with colostomies *plus* a group of 60 less 6<sup>1</sup> alive and well without.

If these figures gave a true estimate of the choice available it would be difficult to agree that restorative resections should be performed more

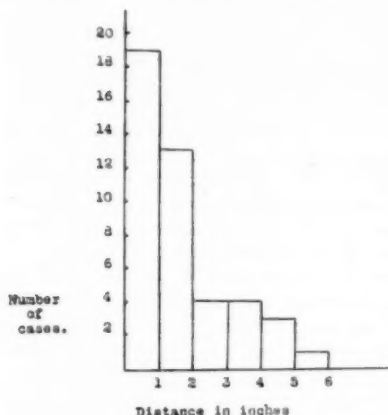


FIGURE I. Diagram to show the extent of the proven lymphatic spread from the upper edge of the primary tumour in the 42 "C" patients who survived for five years after an abdomino-perineal, perineo-abdominal or synchronous combined excision for carcinoma of the rectum.

frequently and that the sacrifice of six patients in order to avoid a permanent colostomy in the other 54 was warranted;<sup>2</sup> but, fortunately, these figures have been based on the assumption that a restorative resection may be associated with a more limited resection of the lymph glands. If, in the absence of hepatic metastases,<sup>3</sup> the ligation of the inferior mesenteric pedicle is performed early in the course of the operation, that is, immediately it is ascertained that the tumour is resectable and before a final decision is made whether it would be otherwise possible to carry out a restorative resection, then the maximum possible lymphatic field will be removed. Under such circumstances there should be no difference in the occurrence rate of lymph gland metastases after the restorative and the combined radical operations, and none of the six need be sacrificed.

Up to this point in the discussion it has also been assumed that the restorative and the combined radical procedures have the same operative mortality and morbidity rates. This, however, is not necessarily so, since the restorative resections must carry the added risks of infection at and around the anastomosis and of recurrence of the tumour at the suture line.

The slightly higher post-operative morbidity rate after restorative resections is of little real importance compared with the mortality rate and may be discounted in this discussion.

If we now consider the difference in the mortality rates we have on the one hand the choice of 120 patients alive and well with permanent colostomies or, on the other hand, the choice of 60 patients alive and well with colostomies *plus* 60 or less alive and well without permanent colostomies. The number, if any, by which this latter group is less than 60 will depend partly on the difference in the mortality rates of the restorative and of the combined radical procedures, and also partly on the incidence of local malignant recurrences after restorative resections. The difference in the mortality rates

<sup>1</sup> Six is the number of patients that it is supposed would be lost if half of the series were submitted to a restorative resection.

<sup>2</sup> There are some surgeons who might agree with this—for example, Mahorner,<sup>(14)</sup> who has suggested that it may be better to have 40 patients alive and well without colostomies than 50 with. The patients who have been cured of cancer of the rectum are, despite the colostomy, usually very pleased to be alive; and, if it were put to them at some time after the operation, very few would agree with Mahorner's suggestion.

<sup>3</sup> The presence of hepatic metastases provides an excellent reason for attempting a restorative resection without the customary wide excision of the lymph glands.

should be less than 1%, and with improved surgical technique the incidence of local recurrences after restorative resections should also be very small. The cause of these recurrences is still obscure, but they are probably due to the fragmentation of the surface of the tumour during the operation followed by implantation in the cut ends of the bowel. The possibility of such implantation should be borne in mind throughout the operation and every effort made to prevent it.

From the above discussion it may be concluded that the continued and more frequent use of restorative resections is justified, for, while aggressiveness in the treatment of carcinoma of the rectum is to be applauded, there is probably some limit to the number of patients who should be submitted to a combined radical resection of the rectum and a permanent colostomy in the hope of curing a single extra patient. Any such chosen limit may be attained by a sufficient reduction in the difference between the mortality rates of the restorative and of the combined radical operations together with a reduction in the incidence of local recurrences after restorative resections.

#### SUMMARY.

From a study of the lymphatic spread in a series of patients with carcinoma of the rectum who were alive and well five years after abdomino-perineal, perineo-abdominal or synchronous combined excision of the rectum, it is concluded that the continued and more frequent use of restorative resections of the rectum is justified.

#### ACKNOWLEDGEMENT.

The figures contained in this paper are based on patients under the care of the honorary surgeons of Saint Mark's Hospital; and the pathological reports were prepared by Dr. C. E. Dukes and Mr. H. J. R. Bussey, B.Sc. My thanks are due to Dr. Dukes for access to these pathological reports and for his help with the preparation of this paper.

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## Case Reports.

### HYDATID CYST OF THE BRAIN.<sup>1</sup>

By P. STANLEY FOSTER,  
*Christchurch, New Zealand.*

HYDATID CYSTS of the brain are, in our experience here, very uncommon. In our General Hospital, where the incidence of hydatid disease is high, there have been only two proved cases of brain involvement in the last twenty years. Dew has pointed out the rarity of primary hydatid disease in the brain and also emphasizes the fact that it is comparatively more common in childhood and that the prognosis is extremely gloomy. It is interesting, therefore, to record the successful removal of a primary cyst from the occipital region of the brain of a man of thirty-four years.

#### Clinical History.

The patient, who was a farmer, was sent to me by Dr. A. B. O'Brien, an ophthalmologist, who found that he had an homonymous hemianopsia. He was admitted to Christchurch Hospital on May 29, 1926, for investigation.

He gave a history of headaches, mostly over the occipital region, for three weeks. He had been vomiting daily for the same time. The vomiting was of a projectile character. He complained of a curious visual disturbance, which he compared with water running down a pane of glass. The previous history was negative save for a war wound in his shoulder in 1917.

On examination the patient was seen to be a well-developed man in good condition; he had been working up to the time of his admission to hospital. Systematic examination revealed no abnormality. The heart and lungs were normal. The systolic blood pressure was 170 and the diastolic pressure was 70 millimetres of mercury.

Examination of the nervous system revealed no motor or sensory disturbance and the reflexes were normal. There was a degree of ataxia—a tendency to fall and bear to the right when the patient closed his eyes. The vision of both eyes was  $\frac{1}{4}$  and the pupils were active. Bilateral papilloedema was present to the extent of about 1.6 millimetres. Examination of the fields of vision revealed marked left homonymous hemianopsia. Lumbar puncture yielded clear cerebro-spinal fluid not under increased pressure. The Wassermann test produced no reaction. The response to the hydatid complement fixation test was negative. The blood was normal; there was no eosinophilia. The urine was normal.

A diagnosis of intracranial tumour in the right occipital region was made. Hydatid disease was discussed, but there was no confirmation in tests to support the suggestion.

Operation was performed on June 14, 1926. An osteoplastic flap was turned down over the right occipital pole. The dura was found under increased tension. A dural flap was made and bulging brain was exposed, the convolutions being completely flattened. A brain trocar drew clear fluid, and on incision of the cortex a hydatid cyst was obvious. The fluid was aspirated and then the collapsed cyst wall was easily removed. It was about as large as a tennis ball, and as the cavity left was considerable, a rubber dam drain was inserted and the flap closed. The operation took less than two hours and the patient's condition throughout was excellent. The drain was removed in forty-eight hours and the wound healed by first intention.

A progress note on June 20, 1926, reports the patient as saying that his vision was much improved.

The ophthalmic department reported normal vision on July 9, 1926, and he was discharged the next day.

#### Subsequent History.

Nothing more was seen of the patient until eight years later, when he was readmitted to hospital with a compound palmar ganglion. He had no signs of any intracranial lesion and appeared normal.

<sup>1</sup> Accepted for publication on July 28, 1948.



# A CASE OF OMENTAL NECROSIS FOLLOWING TRAUMA.<sup>1</sup>

By GEOFFREY NEWMAN MORRIS,  
*Melbourne.*

## Clinical History.

ON February 7, 1947, M.M., a male aged forty-five years, was working in employment as a fitter. A bar of steel, about six feet long by fifteen inches broad, swung suddenly and hit him hard across the abdomen, striking mainly just above and to the right of the umbilicus. He suffered no abdominal pain at the time, but was conscious of what he described as a soreness in the stomach; this did not interfere with the man continuing his work.

Three days later the patient noticed a "catch" in the right groin when he coughed. On investigating he noticed, for the first time in his life, a lump in this area; it was about an inch long and not tender. In 1942 this man had been examined for military service and no hernia had been found.

Generalized abdominal pain, worse on the right side, was first noticed four days after the accident. Pain increased and the inguinal mass became larger and more tender and eight days after the accident the patient was admitted to Prince Henry's Hospital with a provisional diagnosis of strangulated right inguinal hernia.

It was then noticed that the patient was a healthy-looking man, but rather flushed. His temperature was 98.6° F., his pulse rate 84 and respiratory rate 24 per minute. His abdomen was lax; there was no rigidity but some diffuse tenderness was present in the right iliac fossa. In the right groin there was a large, tender, irreducible swelling passing into the scrotum. Rectal examination revealed no abnormality.

**Operative Findings.**—Operation was performed under ether anaesthesia induced by the "open" method. An incision was made in the right groin parallel to the inguinal ligament and the hernial sac was opened. There was an indirect inguinal hernia containing hæmorrhagic omentum. An attempt was made to deliver normal omentum through the internal inguinal ring, where there was no constriction, but this failed. The abdominal cavity was then investigated with two fingers through the internal ring. It was found that the omentum in the hernial sac was continuous with a large mass lying in the pelvis behind the bladder. This mass could not be delivered into the wound.

Accordingly, a right paramedian incision was made and the mass was delivered through this. The mass consisted of the larger part of the great omentum; it was hæmorrhagic and necrotic and of sponge-like consistency and was loosely held in the pelvis by fresh adhesions. There was a clear line of demarcation between healthy and hæmorrhagic omentum with no indication of torsion whatsoever. The omentum was divided just proximal to this line and the diseased area was removed.

The paramedian wound was closed in layers and the hernial wound was closed after removal of the hernial sac and narrowing of the internal ring by suturing the *fascia transversalis*.

Convalescence was uneventful and the patient was discharged to a convalescent hospital nine days after operation.

## Pathological Report.

The pathologist made the following report:

**Macrosopic.** A mass of omental fat eighteen centimetres by ten centimetres in area together with a rounded mass five centimetres in diameter. The larger portion of the fat is dark red and hæmorrhagic in colour.

**Microscopic.** Section through the firm nodule in the omentum shows a diffuse hæmorrhage through the omental fat. There is some hæmorrhage between the folds of fat tissue to lie on the peritoneal surface.

The serosal layer is in places swollen and prominent and there is an early stimulation of the underlying fibroblasts. Some vessels show fibrinoid change in their walls, and there is a mild cellular reaction, mainly polymorphonuclear in type, in the surrounding tissues. There is some vascular damage, mainly to small vessels, and diffuse hæmorrhage throughout the fat and on the surface of the omentum.

<sup>1</sup> Accepted for publication on November 20, 1947.

### Discussion.

Factors (apart from inflammatory lesions) which may cause omental hæmorrhage or thrombosis leading to necrosis are: (a) strangulation in a hernial sac, (b) torsion of the omentum, (c) idiopathic thrombosis, (d) trauma.

Barsky and Schwartz<sup>(1)</sup> subdivide torsion of the omentum into two groups: primary, with no apparent cause, and secondary, associated with herniæ, tumours, cysts and other pathological changes of the omentum.

In secondary torsion of the omentum associated with inguinal hernia the hernia is classically scrotal in type, of long duration, easily reducible and usually on the right side. But for the absence of any sign of omental torsion the case reported would fall into this category.

Pines and Rabinovitch<sup>(2)</sup> have reported six cases and Totten<sup>(3)</sup> has reported two cases of what they term "primary idiopathic segmental infarction of the greater omentum". The clinical history is the same as is seen in omental torsion and the pathological appearance much the same. There is, however, no history of trauma and no evidence of torsion.

Case reports of omental necrosis, unrelated to torsion, but associated with a definite history of trauma, are uncommon.

Hertzler<sup>(4)</sup> collected thirty-four cases in the literature up to 1919 in which omental hæmorrhage followed blunt abdominal trauma. He states that, generally speaking, traumatism to the omentum and mesentery is overshadowed by perforation of hollow organs or rupture of solid viscera.

Schottenfield and Rubinstein<sup>(5)</sup> reported a case in 1941 and review previous case reports, including those of Bush<sup>(6)</sup> in 1896 and Hunter<sup>(7)</sup> in 1904. (Hunter's case followed insertion of a pessary.) They also mention cases in which omental abscesses have been found under the site of previous abdominal trauma. The case reported by Schottenfield and Rubinstein was that of a seven-year-old boy who was kicked in the abdomen by a playmate and had suffered abdominal pain for six days before operation.

Early reports of cysts in the omentum draw attention to the fact that there has usually been a definite history of previous abdominal trauma.

In 1887, in *The Lancet*, Gooding<sup>(8)</sup> reports a case of an omental cyst discovered at operation. There was a history of a severe blow on the abdomen some months before the operation, which was done in 1882 under the carbolic acid spray, a practice which the author states he subsequently abandoned.

In 1898, also in *The Lancet*, Braithwaite<sup>(9)</sup> reports a case of a girl of four years of age who had a large cyst of the great omentum containing three to four pints of fluid. Two years previously the child's body was noticed to be very much bruised, though the cause could not be ascertained.

The main points of interest in the case reported are:

1. The diagnosis of a strangulated inguinal hernia containing omentum which led to operation. In a search of the literature no similar case has been found in which omental necrosis following trauma has involved the omentum in a hernial sac or, as is more likely, the hæmorrhagic omentum has found its way into a hernial sac. The absence of any sign of omental torsion is not consistent with a diagnosis of the more common condition of secondary omental torsion.

2. The need for two incisions to remove the necrotic omentum. The abdominal mass was too large to be removed through the inguinal incision, and delivery of the hernial omentum from the region of the scrotum would have been most difficult through the abdominal incision.

3. The necessity in operating on patients with strangulated hernia containing omentum of visualizing normal omentum above the proximal level of infarction. Cases of combined abdomino-hernial torsion have been reported in which the abdominal lesion was missed because of a failure to realize this point.

4. The importance of the history of trauma and the absence of torsion as an operative finding in relation to liability under the *Workers' Compensation Act*. Liability has been accepted by the insurance company in this case.

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## DIVERTICULUM OF THE APPENDIX.<sup>1</sup>

By O. J. ELLIS,  
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Mr. L.O., aged nineteen years, was admitted to Newcastle Hospital on April 30, 1947, for an interval appendicectomy. There was a history of two previous attacks of

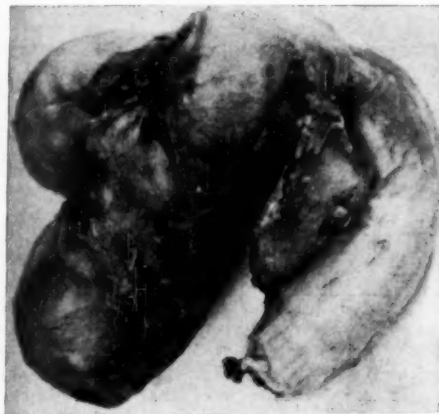
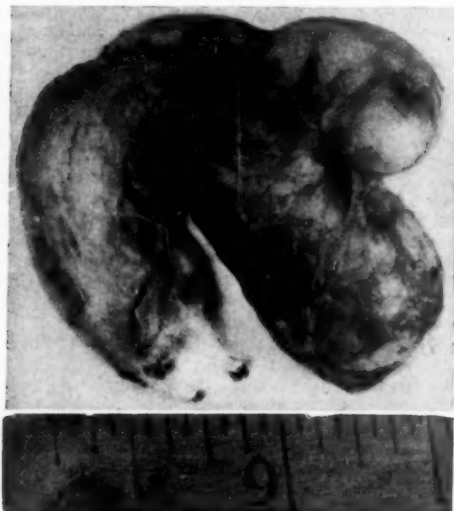
appendicitis, the first one six months previously and the second attack three weeks prior to his admission. On the occasion of the last attack he was off work for only one day. Apart from this there was nothing of interest in the past history.

On examination he was a well-built lad. There was slight tenderness on deep pressure over McBurney's point; otherwise the examination revealed no abnormality. An appendicectomy was performed the following day. The appendix was delivered without any difficulty and was immediately seen to be of an unusual type. The subsequent course of this case was quite normal and the patient was discharged from hospital on May 8, 1947, to a convalescent ward. The following description and the photographs are by courtesy of Dr. Douglas, of the pathological department.

The specimen consists of appendix of overall length 5.0 centimetres. It became progressively wider from the base to the tip, the base being 8.0 millimetres in diameter and the tip 15.0 millimetres in diameter. About

3.0 centimetres from the tip there was a bifurcated diverticulum measuring 3.5 centimetres from the tip of one point to the tip of the other. The diverticulum and the distal portion of the appendix contained faintly opalescent fluid in which were floating white coagula. The whole of this cavity was smooth-walled. The appendiceal wall at the base was greatly thickened, apparently blocking the lumen.

Microscopically the appendix proper comprises the usual layers, but the protrusion is seemingly of the nature of a hernia, for it lacks the muscular coat. Furthermore, the epithelium in the protrusion is present only in limited areas and is then represented by a simple layer of cells devoid of glandular structures. In the appendix proper lymphoid follicles are prominent and inflammatory cells are noted, whilst in the diverticulum inflammatory cells are infrequent. The findings suggest that a mucocele of the appendix has been formed by obstruction of the lumen at the base and that the appendix has become distended by mucus formation, and that perhaps the hernial protrusion resulted from the same pressure.



<sup>1</sup> Accepted for publication on August 20, 1947.

## Abstracts from Current Literature.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

### THE BURIED EPIDERMIS GRAFT.

Ernest Bors and A. E. Comarr: "The Buried Epidermis Graft", *Surgery, Gynecology and Obstetrics*, Volume lxxxvii, July, 1948.

THE buried epidermis graft revives an old and apparently efficient method of skin grafting decubitus ulcers. Originated by Braun in 1920 and first applied by Wangenstein in 1928 as the "implantation method of skin grafting", it has been applied to burns, bedsores, empyema cavities and chronic ulcers, but in the article under review only decubitus ulcers (especially following cord injuries) were treated. The aims are (a) permanent closure or (b) temporary closure to allow speedier use of plastic procedures.

Pre-operative care should be general, and local preparation consists in the use of hypochlorites to provide good granulations. The method is to cut a thin Thiersch graft and to subdivide it into smaller pieces, each  $0.3 \times 0.3$  centimetre. Then each "seed" is introduced by means of a round-bodied needle into the bottom of a cavity made also with a round-bodied needle at an angle of  $35^\circ$  in the granulation tissue, a start being made at the lowest part so as to avoid clouding of the field by blood. The holes are 1.0 to 1.5 centimetres apart. The area is covered with fibrin foam and dressed with furacin and boric ointment. A firm dressing is applied for from five to seven days. Dressings are changed every two days and acetic acid dressings are used to control any pyocyanous infection. In the second week grey patches of epithelium appear and coalesce, and if necessary any bare patches can be retreated after the first ten days. Healing is usually complete in from three to six weeks.

The cosmetic result leaves much to be desired, but it is claimed that in over fifty cases reported the method is quick, simple and thrifty of skin, as well as efficient.

P. J. KENNY.

### FREE SKIN GRAFTING.

John A. Jenney: "Free Skin Grafting", *The American Journal of Surgery*, Volume xlii, July, 1948.

THE author states that all published methods of grafting give good results and queries the accepted theories on grafting.

He points out that epidermis develops from ectoderm and dermis from mesoderm, and epithelium from all three embryonic layers, and that surface coverings all work to keep a fundamentally wet tissue dry on the outside, epithelium being watertight. His postulate is that the use of free skin grafts is to keep in vital fluid. Epidermis lives on tissue fluid without any direct blood supply and therefore can survive anywhere in the body, even on bone. There are two requisites for growth of transplanted epidermis: (a) a sterile, dry bed, (b) the availability of adequate tissue fluid. He attributes great toughness to epidermis in surviving. The time for a free graft is when the patient can stand a minor operation. The surgeon is not concerned with general conditions if epidermis is applied properly; for example, time should not be wasted in building up the patient if a raw area exists.

Between epidermis and dermis is a layer of thin fibrous tissue bundles which allows tissue fluid to permeate to the epidermis, and the sole aim in grafting is to help Nature reconstruct this zone.

Four factors are considered:

*Technique.*—(i) Granulations are removed by caustic silver nitrate and then washed off with saline solution. The silver chloride precipitate is removed by a knife at the level of the collagenous tissue between primary tissues and outside world. (ii) Pressure is applied by dry bandages for five minutes until bleeding stops. (iii) Grafts are applied and massaged until a "fixed feel" is experienced. This completes the operation. (iv) The graft is easier to handle if backed with "Vaseline" gauze. (v) Large areas can be covered by "continuous epithelialization"—the graft is cut into strips and so the growing edge surface is increased.

*Blood Clot.*—Success in grafting depends on fixation of the graft to the host by clot and not by bandages. Post-operation appliances are merely for protection.

**Secondary Tissues.**—Fibrous tissue (and its precursor granular tissue) must be removed to allow vital fluid to get to epidermis. The only use of granulation tissue is early when it has a very small amount of fibrous tissue in the base.

**Post-Operative Cure.**—Post-operative care consists in protection only. Dental wax pressure is used for areas like the hand. Wet cotton wool pressure is used on irregular areas.

The author apparently has no faith in free grafting on healthy granulations, in bacteriological control or in pressure to ensure apposition and control clot.

P. J. KENNY.

#### PROLAPSE OF THE GASTRIC MUCOSA.

I. A. Ferguson: "Prolapse of the Gastric Mucosa: Report of Six Cases", *Annals of Surgery*, Volume cxxvii, May, 1948, page 879.

THE first case of this condition was reported by von Schmieden in 1911. In 297 examinations of the upper part of the gastro-intestinal tract made at two hospitals 23 patients, or 7.7%, were found to have prolapse of the gastric mucosa. (In four cases the condition was sufficiently extensive to indicate the necessity of eventual treatment by surgery.)

The usual age of these patients is in the fourth decade. Pain is the most consistent single symptom. It is either aching or cramp-like in character, it is usually epigastric in position, and it frequently radiates to either the costal margin or the back. Nausea and vomiting occurred in five of the six cases. Four of the six patients had "sour belches" or heartburn. Four had had hæmatemesis and melena. The patients thus presented a variable group of symptoms similar to those presented by patients with peptic ulcer.

X-ray examination is an essential aid in the making of a diagnosis, and fortunately the findings of this examination are distinctive. There is a central filling defect in the duodenum characterized by a central streak of barium showing an intact mucosa. The mucosa prolapsing into the duodenum allows the barium to flow around it, producing a characteristic "mushroom" or "umbrella" effect. The defect is generally not seen in films made with the patient in the erect posture and is often not seen on fluoroscopic examination.

Curative treatment is unquestionably surgical and consists in short-circuiting the diseased area, or removing the prolapsing mucosa, or enlarging the gastric outlet so that the prolapsed mucosa can move back and forth at will. Persistent pain, hæmorrhage and obstruction are indications for operation. The pathology of the condition is an abnormal mobility and redundancy of the prepyloric mucosa with prolapse of this through the pylorus.

JOHN DEVINE.

#### CHOLANGIOGRAPHY.

H. Hagan and H. L. Townsend: "The Clinical Evaluation of Cholangiograms", *Annals of Surgery*, Volume cxxvii, May, 1948, page 795.

It has become a well-established routine procedure to take a "delayed" cholangiogram with the opaque medium injected through the drain which remains of the common duct after its exploration. The fact that a delayed cholangiogram occasionally shows a stone in the common duct suggests that the various methods in use for examining the common duct at operation (for example, palpation and the use of probe, scoop, forceps and irrigation *et cetera*) do not give positive proof that all stones have been removed. "Immediate" cholangiograms have had a limited trial because of technical difficulties and the lack of easy access to X-ray equipment and personnel.

With the cooperation of all personnel concerned the authors have been able to secure satisfactory immediate cholangiograms in a high percentage of cases, the failures being due to too active respiratory movements in large and "thick" patients.

As a routine procedure they place a portable Bucky diaphragm on the operating table between divided pads. All the instruments are removed before the X-ray exposure, and towels are sutured to the peritoneum and towel clips are not used. The opaque medium is injected from a 20 cubic centimetre syringe through a ureteral catheter, which is introduced through a small transverse incision in the cystic duct. Serial films are taken and the cystic duct is then cut across above the ureteral catheter, which is allowed to remain in place while the removal of the gall-bladder is completed and the films are being developed. If the films are satisfactory the catheter is then removed and the stump of the cystic duct is transfixed and ligated in the usual manner.

The authors found that a 35% solution of "Diodrast" was the most satisfactory contrast medium, while lipiodol was most unsatisfactory. The X-ray equipment



consisted of a bedside unit (110 kilovolts and 20 milliamperes). They consider that immediate cholangiograms will give useful and desirable information in the following types of cases: (a) In immediate operations for acute cholecystitis. Where cholecystectomy is being performed an immediate cholangiogram often gives invaluable information. (b) In elective operations for chronic cholecystitis and cholelithiasis. An immediate cholangiogram can be performed by injecting the opaque medium through the cystic duct, the gall-bladder or the common duct, and is of great assistance.

Anomalies of the ductal system encountered at operation are outlined by an immediate cholangiogram when the opaque medium is injected through the cystic duct or gall-bladder; this gives the surgeon "assurance and comfort" by furnishing an immediate visual demonstration of the duct system.

JOHN DEVINE.

#### SUPRARENAL PARAGANGLIOMATA.

R. Fontaine and J. Warter: "*Paragangliome juxta-surrénalien (pheochromocytome) hypertensif, opéré avec succès. (Les troubles de la glyco-régulation dans l'hypertension paroxystique)*", *Lyon Chirurgical*, 1948, page 36.

The fact that certain tumours associated with the suprarenal glands have the power of producing paroxysmal attacks of hypertension is now well known, knowledge of them having passed through several stages. First there were reported cases of young people who at autopsy were found to have suprarenal tumours associated with an unexpected and unexplained cardiac hypertrophy. Then came the "anatomical period", roughly from 1893 to 1912, during which various workers studied these tumours and established their connexion with both the suprarenal and the sympathetic system tissues. Pick distinguished two types, one developed from ganglionic tissue, the other taking its origin from suprarenal medullary cells, which latter, owing to its chromic affinities, became known as a pheochromocytoma. It is this second type only which produces cardio-vascular changes. It was not until 1922 that Labb, Tinel and Doumer discovered the fact that this tumour produced paroxysms of hypertension, with intervals of normal tension. The first of such tumours was successfully removed by Charles Mayo in 1927. Recent estimations are that 44 such operations have now been performed, with 34 cures and 10 deaths.

Certain points in the pathology of the condition can now be said to be definitely known. Paragangliomata, whether suprarenal or juxta-suprarenal, will cause even in their early stages the characteristic symptom of paroxysmal hypertension with return to normal pressure levels between paroxysms. In the later stages this hypertension passes into a chronic form, permanent and with evident participation of the kidneys in the disease process. The nature of the pathological change is essentially endocrine, deriving directly from the chromaffin tumours, in spite of the intermittent nature of the symptoms. The tumours are undoubtedly suprarenal in nature, their adrenaline content varying between 0.5% and 30%. Removal of the tumour always cures the symptoms, though it is to be noted that similar paroxysmal attacks of hypertension can occur apart from the presence of a paraganglioma and have been noticed in cases of pure suprarenal tumours.

The following case report illustrates the condition and some of its interesting features.

A man, aged thirty-two years, stated that he had always been well until five years previously, when he had been involved in a motor accident. Since that time he had suffered from transitory headaches, but had not sought medical aid for them. Shortly after this accident he was awakened at midnight one night by a precordial pain which radiated up to his head. Every beat of his heart, he said, felt like a hammer stroke on his skull. This lasted for a few minutes, then ceased, but in a few moments recurred. In the following year attacks of this type became more frequent and lasted longer. Medical examination at this time failed to reveal any physical cause for them. Four years later he came under the authors' care, suffering from the sudden unheralded onset of attacks of weakness, pallor, cold extremities and tremor, associated with a painful sensation of over-vigorous heart beats. Again he likened these to hammer strokes on his head. After a short time the whole set of symptoms vanished. Complete general examination during remissions revealed nothing relevant to the condition. A glucose tolerance curve rose from 1 milligramme to 30, 30, 1.59, 1.40, 1.34, 1.07. The blood pressure varied only between 120 and 70 millimetres of mercury systolic and diastolic and 150 and 70 millimetres systolic and diastolic, and the electrocardiogram was normal. During an attack the systolic blood pressure varied between 110 and 260 millimetres of mercury, the diastolic pressure between 70 and 160 millimetres. Estimated at the height of such an attack, his blood sugar content was 1.05 milligrammes per centum. The diagnosis of a paroxysmal hypertension based upon a paraganglioma was made.

The localization of the tumour was difficult in the absence of any guiding symptoms. Clinical examination indicated that the abdominal cutaneous reflexes were much diminished on the right side, but this did not seem at the time to bear directly on the diagnosis. On the grounds, mistakenly as it later appeared, that the great majority of these tumours had been reported as being on the left side of the body, exploration of the left renal region was performed, but no tumour was found. The upper lumbar ganglia, the splanchnic nerve and a horn of an enlarged semilunar ganglion were removed. This procedure had no effect on the course of the symptoms. A month later the right side was explored and a rounded tumour, eight centimetres in diameter, was immediately found almost enveloping the upper pole of the kidney. It was dissected free without difficulty and was found to be interposed between the kidney and the suprarenal gland, which appeared to be quite normal in shape and size. There was evidence of a light adhesion between this gland and the tumour at one spot, but it was impossible to say whether this was a secondary adhesion or was evidence of original development from the gland substance. The tumour was apparently benign in structure and separated by a definite capsule from the suprarenal tissue. The histological structure was homogeneous and quite decidedly of endocrine type.

During the operation, at the moment when the tumour was isolated, the patient's systolic blood pressure rose suddenly to 220 millimetres of mercury and thereafter fell steadily to 70 millimetres, without the appearance of any shock symptoms. At the close of the operation the systolic blood pressure was 120 and the diastolic pressure 60 millimetres of mercury, at which level it has remained since.

Commenting on this experience, Fontaine and Warter stress the following points. The diagnosis of the presence of a paraganglioma of hypertensive type was obvious from the clinical condition, but there were no indications whatever to give assistance in localizing the side on which it lay. They ask surgeons who may meet such cases to see if their finding of diminution of the abdominal reflexes is repeated and has any bearing on the position of the tumour. Hypertensive paragangliomata are essentially pheochromic, their physiological activity being demonstrated by their chromaffinity, their siderophilia, and the endocrine pattern of the arrangement of their cells relative to the vessels. Non-hypertensive paragangliomata are in a different class altogether and belong to the group which includes such tumours as those of the carotid body.

The absence of hyperglycæmia in this patient is contrary to the usual experience in suprarenal crises. In most cases of pheochromocytoma it has been reported that the blood sugar level is raised during the paroxysms, parallel with the arterial tension. This case, and some others also, show that this hyperglycæmia is not an absolutely essential accompaniment of the crises. The authors suggest as an explanation that the secretion of the tumour may not be a true adrenaline, but may be another amine, such as the mono- or aphenolic amines, which, while possessing the property of raising the blood pressure, lack the adrenaline power of producing hyperglycæmia. They ask that this point be borne in mind when further such cases are encountered.

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#### ANÆSTHESIA OF THE CAROTID SINUS IN THE TREATMENT OF POST-OPERATIVE SHOCK.

R. Guillet and Estragnat: "*Choc post-opératoire. Anesthésie du sinus carotidien. Guérison. Rapport de P. Wertheimer*", *Lyon Chirurgical*, 1948, page 120.

THE following case report was presented before the Surgical Society of Lyons on November 27, 1947, in order to demonstrate the efficacy, at times almost miraculous, of the infiltration of the carotid sinus with "Novocain" in patients suffering from post-operative or traumatic shock.

A woman, aged forty-nine years, was admitted to hospital suffering from essential hypertension, with intense headache and intermittent transitory hemiplegia. Her systolic blood pressure varied between 240 and 270 millimetres of mercury. A course of eight splanchnic infiltrations produced some reduction of this pressure to about 220 millimetres and the headache was to some degree eased.

Under spinal anaesthesia a thoraco-lumbar sympathectomy was performed, the lower six thoracic and the upper two lumbar ganglia being resected, as well as the left splanchnic nerves. At the start of this operation the patient's systolic pressure was 200 millimetres of mercury; on section of the splanchnics it fell to 160 millimetres and on resection of the sympathetics it dropped further to 130 millimetres, later steadying at the level of 150 millimetres. Twenty-four hours after the conclusion of the operation the patient first began to show signs of shock. Her systolic pressure fell progressively in spite of treatment until it reached 70 millimetres of mercury, and during the same time her temperature rose to a maximum of 40.5° C., and the clinical impression she presented was that of being about to succumb to circulatory failure. This association of shock symptoms with a raised body temperature resembled

the condition known as "pallid pyrexia" in infants. At this stage the right carotid sinus was infiltrated with a 1% solution of "Novocain". The injection was given slowly until 20 cubic centimetres had been injected. While the injection was in progress the patient's condition obviously improved. Her blood pressure steadily rose to 170 millimetres of mercury systolic and 100 millimetres diastolic, then 180 millimetres systolic and 120 diastolic, and fifteen minutes after the completion of the injection it steadied at 210/120 millimetres systolic and diastolic respectively, and during the succeeding two hours it sank to a systolic reading of 150 millimetres, which was that attained after the operation. The temperature fell also, and in a few hours became normal and remained so.

This case is confirmatory of the claims that infiltration of the carotid sinus may have an almost miraculous effect in its swift rescue of apparently dying patients. The strong clinical resemblance of this patient's course to the syndrome of pallid pyrexia (*pâleur-hyperthermie*) seen in infants is interesting and carries the suggestion that this line of treatment might be strongly indicated in the latter condition. As to the mode of action, the authors quote the theory that the infiltration of the carotid sinus liberates a large quantity of adrenaline, which counteracts the inhibitory influence of the resection of the sympathetics. They admit that this explanation does not bear on the question of the pyrexia.

In the discussion of this paper J. Creyssel stated that the case reported seemed undoubtedly to belong to that group, comprising shocked patients, in which the origin was purely nervous and in which neither operative hæmorrhage nor muscle damage could play any part. In the fortunate absence of an autopsy it was not possible to say that there did not exist a retroperitoneal hæmatoma, which, as Suire demonstrated, might easily be a cause of post-operative shock. However, the case does appear to be one illustrating the truth of the statement made by Leriche many years ago in his book "*Chirurgie de la douleur*", to the effect that shock can be produced by purely nervous action. It is particularly in this type of case that infiltration of the carotid sinus produces its most dramatic effects. The association of pyrexia is interesting. It seems to be relatively frequent in these syndromes of delayed shock, and apparently indicates some trauma to the thermal centres of the diencephalon. The blood pressure curves shown with this case report would seem to exclude any other interpretation than that of a rapid and effective result of infiltration of the carotid sinus, by means of a mechanism which can hardly be simply that of an inhibition of the depressor system, since this could bring about only a much more limited and transitory restoration of pressure level than occurred in the case reported.

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## Reviews.

**The Mechanism of Abdominal Pain.** By V. J. KINSELLA, M.B., Ch.M. (Sydney), F.R.C.S., F.R.A.C.S.; 1948. Sydney: Australasian Medical Publishing Company, Limited. 9½" x 5½", pp. 242 with 16 figures and 8 plates. Price: 32s. 6d. (Australian currency).

THE importance of abdominal pain needs no stressing nowadays and the present work is an interesting contribution in this field. The book is a record of personal observations and impressions in which the author's views on this subject are set forth more fully and consecutively than in his earlier papers. Though the exposition covers a wide field, it naturally does not pretend to be complete, the scope of the book being necessarily limited by its purpose. Thus the author disclaims any attempt to present a complete and systematic description of pain in all abdominal diseases. He is principally concerned with sustaining the general thesis that the mechanism for splanchnic pain does not differ essentially from that for somatic pain and that the viscus itself is an important factor not only in pain but also in tenderness. In doing so, he provides a useful exposition of the problems of abdominal pain, as well as a stimulating attempt at their solution.

In the earlier chapters the anatomical and clinical observations leading up to and culminating in modern conceptions of visceral pain are briefly reviewed. The liberal quotation of the opinions and observations of other authors, from Vesalius onwards, makes the account profitable and interesting. However, there are some surprising omissions and in a work of this nature one would like to have seen as much attention paid to recent developments as has been devoted to some of the older observations. Thus there is no reference to the concept, developed in Livingston's excellent monograph on pain mechanisms, which is based on much recent neurophysiological research and which has certain features in common with the "irritable focus" theory of Mackenzie. In brief it postulates that afferent impulses may create abnormal states of activity in the internuncial neuron pool of the cord which may become self-sustaining and self-reexciting and which may not only express themselves

peripherally but may eventually involve other functionally related spinal and brain centres.

The succeeding chapters are devoted to a consideration of such subjects as "Visceral neuroses and the integration of the patient", "Does segmental visceral pain exist?", "Tenderness", "Rigidity" and "The effective stimulus". Then follow accounts, based on personal observations, of abdominal pain in a variety of abdominal lesions: the parietal peritoneum and adhesions, the stomach and duodenum, appendix, biliary channels, intestine and greater omentum, anal canal, genito-urinary system and acute pleural and pneumonic lesions. The concluding chapter takes the form of a brief summary of the contents of the book. The arrangement of the bibliography, in which authors are listed and numbered in the order of their appearance in the text, is unsatisfactory if for no other reason than that it is difficult to find a particular author's work when direct reference is made to the bibliography. It would be more useful if authors were arranged alphabetically and the references numbered as they were then listed.

The book is the work of an experienced and observant clinician and will prove particularly useful to the practitioner and student, to whom it can be recommended. Though some of the author's impressions have been expressed as settled convictions the book is not likely to give a false impression of finality.

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**Elective Alimentary Rest and the Elimination of So-Called "Paralytic Ileus" after Abdominal Operations.** By V. J. KINSELLA, M.B., Ch.M. (Sydney), F.R.C.S., F.R.A.C.S.; 1948. Sydney: Australasian Medical Publishing Company, Limited. 8½" x 5½", pp. 35. Price: 3s. net.

UNDER this title Mr. Kinsella presents in booklet form a series of articles which he has published in current medical journals. The post-operative management and treatment as recommended in most textbooks of surgery and so largely adopted by medical men receive strong condemnation.

The administration of purgatives, enemata *et cetera* is regarded as superstition deeply rooted in the minds of doctors, nurses and laity alike, the relic of primitive man's endeavours to eliminate by expulsive methods the evil spirits of disease. No practising and experienced surgeon possessed of a physiological mind and outlook could disagree with or criticize Mr. Kinsella's doctrines of post-operative treatment.

The basic physiological principle of rest to injured and inflamed tissues is the theme of this booklet, in which the author describes with clarity and in convincing manner the method adopted to give the alimentary tract rest. One must agree with Mr. Kinsella that many patients have been precipitated into a state of "ileus" through the injudicious post-operative administration of purgatives, enemata and alimentary tract stimulation.

The author's series of 344 cases of acute appendicitis of all grades of severity, with no deaths resulting from the disease itself, is convincing proof of the efficacy and soundness of the doctrine of "alimentary rest" in the post-operative treatment after abdominal operations.

It is to be hoped that Mr. Kinsella's booklet receives wide publication and that the principles and methods that he describes and advocates will become the standardized treatment after abdominal operations.

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**A Textbook of Clinical Pathology.** By FRANCIS P. PARKER, M.D.; Third Edition; 1948. Baltimore: The Williams and Wilkins Company. 8½" x 6", pp. 1043, with 229 figures. Price: 67s. 6d.

IN this volume are to be found most of the tests used commonly in the wards and out-patient departments of this country. The techniques are described lucidly, and one of the most valuable features of the volume is the careful criticism of the value of the tests. This is a noteworthy feature of the section that deals with renal function. However, there is one feature that sets a serious limitation upon the value of the book from the medical student's point of view, and that is the inclusion in it of sections of physiology. It is naturally far too wide a subject to receive adequate attention, and the result is the inclusion of material that is more suited to a textbook of nursing, and certainly is far below the standard that is expected from medical students in their clinical years. It is unlikely that this volume will find a place in the teaching of clinical pathology in Australia.

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**Emergency Surgery.** By HAMILTON BAILEY, F.R.C.S., F.R.A.C.S., F.I.C.S., F.R.S.E.; Sixth Edition, Part I; 1948. Bristol: John Wright and Sons, Limited. 10" x 6", pp. 188, with 289 illustrations. Price: 21s. (Sterling) net.

THE sixth edition of this work, which unreservedly may be termed a surgical classic, is to be published in five parts. This innovation has, unfortunately for both the author

and publisher, been compulsory in order to overcome binding difficulties which at present obtain in Great Britain. Our sympathy in this regard is extended to those responsible for this surgical treatise, and we hope that it will not be long before a covering may be obtained commensurate with the worth of its contents.

It is obvious why this work has proved so satisfactory to young surgeons. In the early days of their hospital appointments or in more isolated centres depending on their own resources, they probably knew what should be done but not quite exactly how to do it. Mr. Bailey has drawn from his prodigious surgical experience and has portrayed with exactitude the practice of emergency surgery. Herein lies the real value of his great contribution to surgical literature.

This first volume contains a detailed description of blood transfusion and intravenous therapy, with some advice as to the manner by which the pitfalls of these apparently simple surgical procedures may be anticipated or overcome.

There is no chapter in the book which may be read with greater profit than that dealing with "impending death under anaesthesia". The author's mature views on cardiac massage are vividly described and must command respect. Acute appendicitis is dealt with fully and the author's well-known views of the Ochsner-Sherren or delayed treatment are given in a balanced argument.

We cannot recommend this book too highly to all resident surgical officers and to those being charged with the practice of emergency surgery in the early days of their career.

**British Journal of Plastic Surgery.** Edited by A. B. WALLACE, M.Sc., F.R.C.S. (Edinburgh); Volume I, Number 1 (issued quarterly); April, 1948. Edinburgh: E. and S. Livingstone, Limited. 9½" x 6¼". Price: 12s. 6d. per single volume, 42s. per volume (Sterling).

THIS, the first volume of a new publication, is the official organ of the recently formed British Association of Plastic Surgeons, which represents yet another specialist subdivision within the organization of the Royal College of Surgeons of England.

To plastic surgeons within the Empire, most of whom have trained at the feet of the recognized English masters, this journal, besides being a welcome medium for expression and for publication of accounts of current work, will also form an invaluable additional link between surgeons doing this type of work not only in England but throughout the world. Most of the British work in this sphere has in the past been largely dissipated in its publication.

At first glance one may say that this is just another of many such publications whose appeal is limited to the relatively few who practise the specialty; but there are few surgeons whose work does not bring them into contact with the problems of reconstructive surgery and who should at least know what is going on and what can be done in this field, even though they themselves may not undertake the work. It can therefore be commended to all surgeons and in particular to those who are concerned mainly with trauma and the restoration of function.

This inaugural volume contains communications from most of the major plastic units in England, but perhaps the most interesting reports a determined and refreshing attack on the problem of lymphoedema by Rainsford Mowlem. However, by far the most important contribution is one by J. Paterson Ross, who sets out clearly and with great insight the relationship of this specialty to surgery and surgical teaching in general. All those who practise surgery and who are concerned with clinical surgical teaching would do well to digest carefully this survey by the director of one of the most important surgical teaching units in England.

The journal itself is compact, well produced and well up to the high standard of medical publications set by E. and S. Livingstone, Limited, of recent years.

## BRITISH CONGRESS OF OBSTETRICS AND GYNÆCOLOGY.

THE twelfth British Congress of Obstetrics and Gynæcology will be held at the Friends' Meeting House, Euston Road, London, on July 6, 7 and 8, 1949.

The president will be Sir Eardley Holland and the joint honorary secretaries are Dr. A. Joseph Wrigley and Dr. Ian Jackson, 58 Queen Anne Street (Royal College of Obstetricians and Gynæcologists), London, W.1. The programme is as follows.

### Wednesday, July 6.

Morning Session, 10 a.m. (Chairman, the President).

The Congress will be declared open by the Minister of Health.

"Modern Cæsarean Section", introduced by Mr. McIntosh Marshall (Liverpool).



## Afternoon Session, 2 p.m.

- (1) Guest paper, Dr. Joe Meigs (Massachusetts).
- (2) "Pregnanediol", introduced by Professor C. F. Marrian (Edinburgh) and Dr. G. I. M. Swyer (London).

## Thursday, July 7.

## Morning Session, 10 a.m.

- "Essential Hypertension in Pregnancy", introduced by Professor George Pickering (London) and Professor F. J. Browne (London).

## Afternoon Session, 2 p.m.

- (1) "Hernia of Pouch of Douglas", introduced by Mr. Charles Read (London).
- (2) "The Management of Pregnancy in Diabetics", introduced by Mr. John Peel (London) and Professor D. M. Dunlop (Edinburgh).

## Friday, July 8.

## Morning Session, 10 a.m.

- "Diagnosis and Prognosis of Carcinoma of the Uterus", introduced by Dr. J. E. Ayre (Montreal) and Dr. Spears (Cambridge).

## Afternoon Session, 2 p.m.

- Discussion on Maternal Mortality.

Owing to the difficulties that exist at the present time in arranging hotel accommodation, travel *et cetera*, the honorary secretaries would like to have the names of those who hope to attend by March 31, 1949, at the latest, and, if possible, very much before that date.

### Books Received.

"Medical Research in War." Report of the Medical Research Council for the Years 1939-45; April, 1938. London: His Majesty's Stationery Office. 9" x 6", pp. 456. Price: 7s. 6d.

"A Primer in Clinical Science." By R. Douglas Wright; 1948. Melbourne: Melbourne University Press. 8½" x 5½", pp. 43. Price: 3s. 6d. net.

"The 1947 Year Book of Pathology and Clinical Pathology." Edited by Howard T. Karnser, M.D., and Arthur H. Sanford, M.D.; 1948. Chicago: The Year Book Publishers, Incorporated. 7" x 4¾", pp. 558, with 103 figures. Price: \$3.75.

"The Treatment of Malignant Disease by Radium and X-Rays, being a Practice of Radiotherapy." By Ralston Paterson, M.C., M.D., F.R.C.S.E., D.M.R.E., F.F.R.; 1948. London: Edward Arnold and Company. 9½" x 6½", pp. 632, with numerous illustrations. Price: 45s. (Sterling) net.

"The 1947 Year Book of General Surgery." Edited by Evarts A. Graham, M.D.; 1948. Chicago: The Year Book Publishers, Incorporated. 7" x 4½", pp. 734, with 200 illustrations. Price: \$3.75.

"Encyclopedia of Medical Sources." By Emerson Crosby Kelly, M.D., F.A.C.S.; 1948. Baltimore: The Williams and Wilkins Company. 9" x 5½", pp. 476. Price: 56s. (Australian currency).

This is essentially a dictionary of eponyms and a most valuable reference.

"Source Book of Orthopaedics." By Edgar M. Bick, M.D., F.A.C.S.; Second Edition; 1948. Baltimore: The Williams and Wilkins Company. 9" x 5½", pp. 552, with 31 figures. Price 60s. (Australian currency).

A fascinating account of the development of orthopaedics throughout the ages, followed by a review of the parts played by the application of physiology, morphology and pathology in the development of contemporary orthopaedic surgery. Each chapter carries a large bibliography.

"Laboratory Technique in Biology and Medicine." By E. V. Cowdry; Second Edition; 1948. Baltimore: The Williams and Wilkins Company. 9" x 5½", pp. 296. Price: 30s. (Australian currency).

A reference book, listing short descriptions of techniques with references to the literature as well as eponymous references.

"The Practice of Chiropody." By Keith Campbell Jones; 1948. London: Angus and Robertson. 9¾" x 6", pp. 287, with 23 figures. Price: 42s. (Australian currency).



